Notes

Atomic Energy Control Board | Commission de contrôle de l'énergie atomique

INFORMATION BULLETIN 92-1 **March 2, 1992**

REGULATORY RESEARCH & SUPPORT PROGRAM FOR 1992/93 — PROJECT DESCRIPTIONS

The Regulatory Research & Support Program (RSP) is intended to augment and extend the Atomic Energy Control Board's regulatory program beyond the capability of in-house resources. The overall objective of the research & support program is to produce pertinent and independent information that will assist the Board and its staff in making correct, timely and credible decisions on regulating nuclear facilities and materials.

The program is divided into nine main areas of research covering the safety of nuclear facilities, radioactive waste management, health physics, physical security, the development of regulatory processes, and special services. A total of 93 projects are planned for 1992/93, including a number which are ongoing from the previous fiscal year. Projects that are held in reserve in case funding becomes available ("Category 3" projects) are also listed and provisionally ranked. The spending estimates for the RSP were calculated on the basis of an expected budget of $3.85 M.

Most of the projects will be carried out under contracts issued through the Department of Supply and Services.

This Information Bulletin contains a list of the projects with a brief description of each, and additional supporting information.

Additional copies of this Bulletin, or other information concerning its contents, may be obtained by contacting:

Atomic Energy Control Board
Office of Public Information
P.O. Box 1046
Ottawa, Canada K1P 5S9

Telephone: (613) 995-5894

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92-03563/

REGULATORY RESEARCH & SUPPORT PROGRAM 1992/93

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EXPLANATION OF PROJECT DESCRIPTIONS

A. PROJECT NUMBER (unique to project)

- first digit	number of the Mission Object (see main headings in "Table of Contents", numbered from 2. Nuclear Reactors to 11. Special Services)
- second set of digits	item number (beginning nominally with number 101) within the Mission Object
- third digit	contract or phase number in a sequence of related contracts for a given item number (e.g., a full-scale study [2] following a feasibility study [1]). The number 1 appears even if a project is not subdivided into phases.

B. TITLE

C. SUMMARY
The three paragraphs state:
- WHAT is proposed or in progress and by what means
- WHY this project is proposed
- HOW it is intended to use the results.

The participation, if any, of other organizations is also mentioned.

D. PROPONENT
Originating division within the AECB, or other originator, of the proposal. (Abbreviations refer to AECB organizational units, whose full names are given under "Standard Abbreviations, AECB Organizational Units".)

E. TECHNICAL ADVISOR/EVALUATOR
AECB division (and individual staff member, where known) which gives advice to, or for liaison with, the Project Manager on certain technical aspects of the project. The evaluator assesses the quality of the work done by the contractor and also assesses how the results of the project may be used by the AECB, through a post-project evaluation.

F. PROJECT MANAGER
Name of staff member within the Research Divisions responsible for the project (to the extent that the AECB is committed, in the case of joint projects).

G. REVIEW PANEL
The Review Panel is a group of internal and external experts set up by the AECB to give advice to the Project Manager on some or all technical aspects of the project.

H. CONTRACTOR
For projects in progress, the name of the company or institution doing the work is given.

I. PRINCIPAL INVESTIGATOR
If known, the name of the principal investigator is given.

J. CATEGORY
0 - Projects in progress at the beginning of the program year (from preparation of work statement to acceptance of final report).
1 - Projects intended to be initiated in the program year.
2 - Projects which would be Category 1 but will not be initiated until other work is completed.
3 - Projects held in reserve in the event that funds become available in the program year.

K. FUNDING

Past Years	Year Prior to Program Year	Program Year	Year after Program Year	Future Years	Project Total

- Actual expenditures are shown for past years.
- Estimated amount is shown for the program year; but this amount is subject to change. For items in Categories 2 and 3, the amount may be quite speculative.
- Amounts shown for years after the Program Year can be very speculative.

L. RELATED PROJECTS
Earlier directly-related projects are shown by project number along with the previous expenditures.

2.102.1 Design, Analysis and Testing Tools for Real-Time Software

It is proposed to survey the latest developments in computer program design, analysis and testing tools, as applied to real–time critical systems. Then, based on the results of the survey, it is proposed to acquire a software tool to analyze the complexity and verification/validation test coverage aspects of safety–related software.

Due to the combination of the number of inputs and processing pathways, computer programs used to control nuclear reactor systems are difficult to verify and validate manually. The software industry is developing tools to assist software design, analysis and testing. These are sometimes called CASE tools.

The results of the survey phase would provide AECB staff with the latest information concerning what is available, enabling a knowledgeable assessment of the particular tools used by licensees to verify and validate their critical software. A software tool may also provide an effective means for AECB staff to rigorously and independently evaluate a particular system and the extent of test coverage proposed by the licensee.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$40k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

2.105.2 Crack Propagation in Tough Ductile Materials - Carbon Steel

It is proposed to examine the results of carbon steel fracture toughness tests and pipe rupture experiments, and to formulate a theory describing the observed crack behaviour. In addition, it is proposed to evaluate whether the crack growth model which accounts for angled crack propagation is more or less conservative than the classical fracture mechanics approach.

Recent testing performed in the IPIRG program (see project 2.111.1) has shown that crack growth in carbon steel piping material is not across the plane of principal stress, but runs at a sharp angle (approximately 45°) to it. However, current pipe rupture analysis, using linear-elastic or elastic-plastic fracture mechanics, assume that cracks propagate circumferentially to produce a plane-ended guillotine break. These analyses are used in licensing submissions for defect disposition and to demonstrate leak-before-break behaviour. The proposed project would address this discrepancy between the theory and actual crack growth behaviour.

The results would serve as a technical basis for defect dispositioning and other crack stability assessment work and would be used in the assessment of licensing proposals in this area.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	J.K. Pereira
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$25k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.105.1	$99,000
2.111.1	$399,000

2.111.2 International Piping Integrity Research Group - 2

It is intended to participate in Phase II of the International Piping Integrity Research Program (IPIRG-2) after the completion of Phase I (IPIRG-1) by mid 1991. In IPIRG-2, data will be obtained for both quasi-static and dynamic (seismic) loadings, and experiments will be conducted on piping configurations representative of actual piping systems. The new program will also include selected special-effect experiments in support of the pipe system experiments. The USNRC will be the lead organization, with multi-national contributions to the program. The cost of Canadian participation is expected to be shared equally between the AECB and Ontario Hydro (each contributing $300K over 3 years).

The current IPIRG program (IPIRG-1) was completed in July 1991. The work which will be conducted in the new program (IPIRG-2) will build on the solid base of information that has been established in IPIRG-1. The new program will include testing of piping systems, including cracks in straight pipes, elbows and tees. Such information is crucial to assessing licensees' designs.

The information generated by this project would be used in assessing new design concepts such as leak-before-break, defining in-service inspection frequency, and evaluating licensing criteria for protection against pipe rupture.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	J.K. Pereira
Review Panel	
Contractor	USNRC/Battelle
Principal Investigator	M. Mayfield
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$110k	$110k	$110k	$0k	$330k

Earlier Directly-Related Contracts and Funding:

2.105.1	$99,000
2.111.1	$399,000

2.126.2 Critical Channel Power Uncertainty Measurement

A project is proposed to verify the statistical correctness of the uncertainty assessment of the critical channel power (CCP) submitted by the licensees in support of the new CANDU-6 reactor overpower (ROP) trip setpoints.

Previous work done by the Statistical Consulting Centre of Carleton University has indicated that previous CCP assessments lacked in statistical rigor. Since the AECB does not currently have in-house expertise to verify the correctness of the newly proposed procedure, the need for the proposed work is self-evident.

The outcome of this project would allow the AECB staff to make sound judgements in relation to the current submissions, and would afford guidelines on how to perform such work by the AECB in the future.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (C. Snoek)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$45k	$0k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

2.126.1 $18,000

2.128.4 Fire Drill Evaluation at Pickering

A contract is proposed which would evaluate the Pickering Nuclear Generating Station fire-fighting capability assessment program.

AECB staff is concerned that the capability of Ontario Hydro Pickering Nuclear Generating Station (PNGS) site fire crews to cope with a major fire has not been fully assessed or exercised. In response to this concern, Ontario Hydro has made the commitment to determine the adequacy of the fire fighting capability at the PNGS site. The AECB requires an expert review of the assessment program.

The results of this contract will be used by AECB staff to determine whether the utility has demonstrated adequate capability to cope with major fires at the PNGS.

Proponent	PRDA, SEDE
Technical Advisor/Evaluator	PRDA (B. Finnigan), SEDE (K. Asmis)
Project Manager	M. Mortimer
Review Panel	
Contractor	Fire Cross Consultants Inc.
Principal Investigator	Lorne MacLean
Category	2

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

2.128.1	$3,000
2.128.2	$11,000
2.128.3	$14,000

2.148.2 Molten Fuel/Moderator Interaction

It is proposed to conduct a program of experiments to investigate the potential for, and consequences of, steam explosions arising from the interaction between molten fuel and moderator. The experimental set-up would be extensively instrumented (including provision for high speed optical and x-ray photography).

Previous AECB research projects (Projects 84.1.30, 2.120.1 and 2.148.1) on this topic have indicated that the potential for steam explosion due to molten fuel/moderator interaction after a severe fuel channel flow blockage cannot be ruled out. The AECB has completed a small research program involving small scale experiments to provide basic understanding of the steam explosion phenomena. Further experiments and modelling are required to develop an appropriate analytical tool to predict the occurrence and consequences of steam explosion.

The findings of this project would provide information that would be used to assess the consequences of molten fuel/moderation interaction and to enable development and appropriate mitigating measures.

Proponent	SEDA
Technical Advisor/Evaluator	SED (M. Rizk)
Project Manager	J.K. Pereira
Review Panel	23
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$150k	$100k	$0k	$250k

Earlier Directly-Related Contracts and Funding:

84.1.30	$55,380
2.120.1	$50,000
2.148.1	$36,000

2.152.4 Five-Channel-per-Pass CATHENA Code for Darlington NGS

It proposed to modify the input data package for the AECB version of the CATHENA code from the current single-channel per pass to a more detailed five-channel per pass. The input data will be set up in accordance with Darlington NGS design data although a more detailed representation of the reactor, particularly in the region where boiling is expected to occur, is envisaged for this version. In developing the five-channel-per-pass version, emphasis will be placed on two-phase separation phenomena, e.g., flow separation in the reactor headers with possible flow recirculation between the feeders via the headers (without going through the steam generator).

The information on which Darlington NGS safety submissions are based is produced by licensee codes such as SOPHT (and, in the future, TUF), which contain numerous physical models and assumptions. There is a need to have an independent AECB in-house computing capability to perform check runs of the models and assumptions as part of the AECB normal course of evaluating the licensee calculations.

The new version of CATHENA will be used by AECB staff to analyze various accident scenarios. These results will be compared with those produced by the licensee's computer codes.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (V. Tang)
Project Manager	M. Mortimer
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

86.1.22	$16,441
2.152.1	$30,000
2.152.2	$45,000
2.152.3	$30,000

2.152.5 CATHENA Support Service

The services of AECL staff are required to assist in the modification and running of the input for the CATHENA computer program and possible changes to the code itself.

The capability of the CATHENA code to be used as an independent computing capability to perform check runs of licence submissions is known. In order to enhance the accuracy of the information of the results, the present input deck should be modified.

The new version of CATHENA will be used by AECB staff to analyse various accident scenarios and to compare with the results produced by the licensee's computer codes.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (V. Tang)
Project Manager	M. Mortimer
Review Panel	
Contractor	AECL (CANDU) - Sheridan Park
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

2.153.1 Review of the GOTHIC Code and Trial Application

It is intended to review the existing verification and validation of the computer code GOTHIC. In addition, a trial analysis will be performed to analyze the flow behaviour and distribution of hydrogen concentration within the 600 MW reactor containment following a hypothetical LOCA and LOECC.

Since GOTHIC is a licensing code being used by Ontario Hydro, a code review is appropriate. Further, in safety analyses for LOCA and LOECC, the concentration of the hydrogen released inside containment is assumed to be uniform. The validity of this assumption needs to be confirmed particularly when cooling fans are not credited. Hydrogen concentration distribution inside containment is an important parameter in determining the need for ignitors and their most beneficial locations.

The outcome of this study would be used to assist the AECB in its code review and in determining the appropriateness of the safety analysis assumption related to hydrogen distribution and of possible locations of hydrogen ignitors within containment.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (V. Tang, J.W. Blyth)
Project Manager	M. Mortimer
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$45k	$0k	$0k	$65k

Earlier Directly-Related Contracts and Funding:

2.170.1 Reliability of Electrical Motors Under Accident Conditions

It is proposed to determine the functional capability of naturally aged safety system electrical motor windings under accident and post-accident conditions, and to correlate the findings with the results of various non-destructive diagnostic measurements performed before and after the accident exposure. A heavy water coolant recovery motor was removed from NPD NGS containment area for this purpose. The proposed work would involve collection of data on the nature of the service environment, and laboratory tests and assessment at Ontario Hydro Research Division (OHRD).

Reliability of safety system electrical motors under expected accident and post-accident conditions is essential for the effective mitigation of accidents, should they occur. Present non-destructive diagnostic techniques have a limited capability for detecting the degration of motor windings before failure and for predicting the remaining life for normal operating conditions. (Research work at OHRD sponsored by EPRI is addressing this limitation.) These diagnostic techniques are not able, as yet, to predict the performance of motor windings under accident and post-accident conditions.

The proposed work would enhance the development of effective condition monitoring techniques capable of detecting degradation before failure and of predicting remaining life under all anticipated service conditions, including accident and post-accident conditions. The results would improve the capability to assess the findings of diagnostic motor tests and would thus contribute to maintaining operational readiness of nuclear power plant safety systems.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (T. Leung)
Project Manager	W.A. Grant
Review Panel	
Contractor	Ontario Hydro, Research Division
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$100k	$0k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

2.174.2 Hydrogen Absorption-Desorption at Metal Surfaces - Phase 2

The intent of this project is to carry out experiments to demonstrate that oxides of zirconium may react with deuterium to form D2O. This demonstration will involve the use of isotopically labelled oxygen (oxygen-18) to prepare zirconium specimens, before exposing them to gaseous deuterium, then monitoring the molecular mass of the reaction products.

This project will supplement experimental work carried out in FY 1989/90 in project 2.174.1, in which a mechanism for breakdown of the protective oxides in CANDU pressure tubes was investigated. The previous work gave evidence that when oxidized zirconium specimens were heated in the presence of deuterium, reactions took place which produced D2O. However, the experiments did not show conclusively that it was oxygen from the zirconium specimens, rather than from other sources, which participated in these reactions. The proposed experiments using isotopically-labelled oxygen will resolve this criticism and will demonstrate the existence of the postulated mechanism.

The results of this work will be made available to industry, as an indication of a possible line of enquiry into the oxide breakdown observed in CANDU pressure tubes.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (A. Shalabi)
Project Manager	W.A. Grant
Review Panel	
Contractor	University of Toronto
Principal Investigator	Dr. C. Ward
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$50k	$20k	$0k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

2.174.1	$70,000

2.179.1 Performance of Steam Generator Emergency Water Injection

It is intended to conduct an experimental study in which a section of the secondary side of a steam generator would be built to investigate phenomena associated with the emergency injection of water into the steam generator secondary side under accident conditions. The test section would be as close as possible in design to the actual geometry of the steam generators used in the Darlington NGS.

Licensing submissions addressing the effectiveness of the steam generator emergency cooling injection system have treated some of the crucial parameters as uncoupled. AECB staff believe that combined effects such as spray header water distribution, hot wall, and steam flow behaviour would dictate the overall performance of the steam generator emergency cooling system.

The results of this study should provide insight on particular aspects of cold water injection into the steam generator secondary side, and would be used to assess the validity of licensee submissions on this topic.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (H. Tezel), PRDB (C. Wang)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$35k	$55k	$0k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

2.181.2 Computer Code for Contaminant Dispersion and Impact Assessment

It is intended to acquire the airborne dispersion program ALOHA/CAMEO as a tool to assess the impact of chemical releases from nuclear facilities such as heavy water plants. Further, it is intended to incorporate radionuclide information into this program in order to allow it to be used in assessing the radiological impact of radioactive releases from facilities such as nuclear reactors and fuel processing plants.

AECB staff is required to assess the impacts of routine, non-routine and hypothetical airborne releases from nuclear facilities. A user-friendly software package does not currently exist within the AECB to perform such assessments.

The results of the project, a documented software package, would assist AECB staff in assessing the atmospheric dispersion and impact on the public of chemical and radioactive releases from nuclear facilities. In addition, the resulting software package will be used in training modules produced by the Training Centre, and for evaluation of emergency response plans.

Proponent	SEDA, REPD
Technical Advisor/Evaluator	SEDA (L. Truong), REPD (L. Chamney), PCS (B. Howden)
Project Manager	M. Mortimer
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$20k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

2.181.1	$20,000

2.184.3 Ballooning of CANDU Pressure Tubes - Experimental Studies

It is intended to conduct small-scale separate effects tests on as-received, irradiated, and hydrided pressure tube specimens to verify the hypotheses formed from previous phases of this project: a) that uniform hydriding has no effect on ballooning; and b) that irradiation and hydride blisters will affect ballooning. The influence of the ambient environment on pressure tube ballooning will also be assessed in these tests. The experiments would be designed and conducted in accordance with the results of a previous project (2.184.2).

Safety analyses predicted that certain failures in reactor cooling systems could lead to coolant stagnation in fuel channels and to the ballooning and eventual rupture of pressure tubes. Current models of pressure tube ballooning behavour are based on tests conducted with new pressure tube material in an inert environment, and may overestimate the ductility and creep behaviour of end-of-service-life pressure tubes under actual conditions.

The results of this project would lead to an improved ability to predict the strain at failure of rapidly straining pressure tubes by confirming or developing hypotheses about the effects of irradiation and deuteriding of zirconium alloys. This would permit improved assessments by AECB staff of predictions of pressure tube behaviour in accident conditions.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (A. Shalabi), SEDA (L.D. Macdonald)
Project Manager	J.K. Pereira
Review Panel	15
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$8k	$299k	$253k	$325k	$885k

Earlier Directly-Related Contracts and Funding:

2.184.1	$35,000
2.184.2	$42,000

2.187.2 Operational Readiness of Filtered Air Discharge Systems - Phase 2

It is intended to review and evaluate the impact of the Pickering NGS Filtered Air Discharge (FAD) system re-design on the work previously carried out under project 2.187.1. In addition, it is proposed to review the proposed changes in the Post-LOCA Radiation Monitoring System (PLRMS) at Pickering NGS and review the current Post Accident Monitoring Systems (PARMS) at Bruce NGS and Darlington NGS.

The review of the Pickering FAD System under project 2.187.1 was based on an old design, since the information on the redesign was not available at that time. Also, during the review, it was identified that the PLRMS is one of the systems that could play a crucial role in decisions on FAD system operating modes and timing, and on emergency response planning, and could, therefore, affect FAD system effectiveness. The emphasis of this project would be on the engineering design and effectiveness of the system and its impact on the assumptions made in safety analyses.

Results of the proposed work would be used as a technical basis for assessments of the adequacy of the design, testing and maintenance methods of the FADS used in Canadian nuclear power plants.

Proponent	PRDA, SEDA, REPD
Technical Advisor/Evaluator	PRDA (U. Nurmsoo), SEDA (L. Truong), REPD (R. Utting)
Project Manager	M. Mortimer
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$12k	$15k	$0k	$0k	$27k

Earlier Directly-Related Contracts and Funding:

2.187.1	$50,000

2.190.1 Selection of Safety Significant Components of Nuclear Power Plants for Aging Assessments

As Phase 1 of a systematic nuclear reactor plant aging program, it is proposed to prepare structured lists of CANDU nuclear power plant safety-significant components of a) CANDU nuclear power plants and b) Canadian research reactors which are susceptible to aging degradation (the term "components" is used in a broad sense, meaning plant components, systems and structures.) The lists will be determined on the basis of CANDU and research reactor operating experience, expert knowledge, information from equipment qualification and other relevant external programs. Their structure would indicate priority according to which preliminary aging assessments would be conducted for the selected components in the scoping phase (Phase 2) of the program.

Aging degradation of NPP and research reactor components has the potential to adversely affect plant safety if it is not effectively managed. Nuclear reactor plants have thousands of components which experience aging effects to a greater or lesser degree. Because of limited resources, it is necessary to select and rank these components for which comprehensive evaluations of the impact of aging on plant safety should be conducted and effective aging management strategies and methods developed.

The results of this project would provide input for the scoping phase (Phase 2) of the nuclear reactor plant aging research program which constitutes the second step in the selection of plant components for the comprehensive aging assessments to be done in Phase 3 of the program. The program is designed with the intent to a) generate knowledge to identify and resolve emerging and unanticipated problems as they arise, and b) provide technical bases for licensing assessments and decisions relating to fitness for service of plant components and to operational safety of nuclear plants throughout their entire service life.

Proponent	RSDA
Technical Advisor/Evaluator	PRDA (G. Schwarz), PRDB (E.J. Dunstan), SCD (P. French), CQAD (B. Jarman)
Project Manager	J.K. Pereira
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

2.192.1 Effect of Sheath Strain on Critical Heat Flux

It is proposed to investigate experimentally the effect of fuel sheath strain on critical heat flux (CHF). The work would involve the construction of a three-metre long, uniformly-heated bundle consisting of three elements (trefoil); the upstream half would have the nominal dimension of the 37-element CANDU fuel. The heater elements in the downstream half would be three percent larger in diameter. Critcal heat flux experiments would then be conducted for both geometries (nominal and three percent larger) by reversing the flow direction. (Uniform heating implies that dryout would occur at the end of the channel and this would simplify the instrumentation).

The Pickering Unit 1 fuel failure in November 1988 led Ontario Hydro and Chalk River Nuclear Laboratories to conduct detailed examinations of both failed and intact fuel. Results have shown that the intact fuel elements were strained by as much as two percent. However, the effect of fuel sheath strain on CHF has not been experimentally investigated. It appears that subchannel analysis does not provide relevant information, hence experimental data are required to determine the effect of sheath strain on bundle power limits.

Experimental data on the relative reduction in CHF for strained fuel elements as compared to nominal fuel would assist AECB staff in estimating the reduction in the safety margins for CANDU stations containing strained fuel. Based on these results AECB staff could decided whether it is necessary to request the licensees to conduct similar tests with full-scale fuel channels.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (C. Snoek)
Project Manager	J.K. Pereira
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$150k	$0k	$0k	$150k

Earlier Directly-Related Contracts and Funding:

2.193.1 Studies of Hydrogen Combustion Phenomena in CANDU Nuclear Power Plants

It is proposed to study the phenomena relating to hydrogen combustion in multiple jets (parallel and radially interacting) of hydrogen-steam mixtures.

In a nucelar reactor containment, streams of hydrogen-air steam mixtures could be discharged through the openings in the air conditioning ducting at various locations inside the containment. The discharges may be in the form of parallel or radially interacting jets. Jet interaction may create intense turbulence resulting in a very fast deflagration or deflagration-detonation transition. This may result in higher than predicted peak pressure in the vault or a local pressure pulse which may threaten the containment seals around the steam generator or the pump penetrations. This is intended to be a scoping study to determine experimentally the key parameters which may have a significant effect on the combustion processes (e.g. flame velocity, deflagration to detonation transition), and to provide some quantitative measure of these effects.

The results of the work will enable AECB staff to assess the validity of the consequences predicted by the licensee of a hydrogen burn inside the CANDU containment.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (J.W. Blyth)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$200k	$0k	$0k	$200k

Earlier Directly-Related Contracts and Funding:

2.196.1 Statistical Review of Pressure Tube Inspection Data

This project is intended to study possible correlations between pressure tube deuterium measurements from In-Service Inspection (ISI) and tube metallurgical, manufacturing or operational factors. The contractor would obtain available data from pressure tube history dockets and other industry sources.

Deuterium pick-up is a potential life-limiting degradation of pressure tubes. A previous analysis by AECB staff of pressure tube deuterium contents indicates that some tubes are picking up deuterium at rates significantly faster than others; however, no correlation was evident with iron content, channel power, effective full power hours, core location or mass flow rate. It is therefore believed that the cause of the observed variation lies with other manufacturing or operational factors.

A valid predictive relationship between pressure tube manufacturing or operational variables and deuterium contents would enable ISI sampling to be focussed on "high risk" populations of tubes, giving a greater degree of conservatism over the existing, random sampling program.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (I.M. Grant)
Project Manager	J.K. Pereira
Review Panel	
Contractor	J.H. Parker & Associates Inc.
Principal Investigator	Dr. J.H. Parker
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$87k	$14k	$0k	$0k	$101k

Earlier Directly-Related Contracts and Funding:

2.200.1 A Safety Course for Pressure-Tube Type Reactors

It is proposed to develop an annual course which would provide a suitable forum for exposing AECB staff and other national and international nuclear industry personnel to the most recent developments in safety analysis, operation and regulation of pressure-tube type reactors. The proposed project would involve design, development and initial implementation of such a course. The course would be given by experts drawn from the nuclear industry and academic institutions and could be prepared and presented in conjunction with them.

Currently in Canada, there does not exist an appropriate and formally structured program which provides an opportunity for staff of the AECB and Canadian and foreign utilities to focus on current trends in safety analysis, operation and regulation of pressure-tube type reactors.

A custom-made course for participants interested in pressure-tube type reactors would be more effective than similar courses on light water reactors. The course would be used to upgrade the skills of the attendees by providing state-of-the-art information on a wide range of topics related to the design, safety analysis and regulatory aspects of pressure-tube type reactors. The course would also serve to introduce new personnel into the realm of nuclear safety analysis and evaluation.

Proponent	DAA, TC
Technical Advisor/Evaluator	DAA (J.G. Waddington), TC (A. Omar)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$30k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

2.203.1 Intermediate and Full Scale Tests on Hydrogen Burn Phenomena

It is proposed to enter into a cooperative progam, under an agreement with CANDU Owners Group (COG), conducted by KfK and Battelle (Europe) to investigate hydrogen behaviour in containment. The proposed program would include performing experiments in intermediate and full scale, multi-compartment facilities to investigate the effect on hydrogen combustion of equipment size, gaseous mixture composition, multi-compartment configuration and the effects of the presence of steam. In addition, the effect of hydrogen combustion on the redistribution of aerosols and the effectiveness of the catalytic ignitor/recombination unit will also be studied.

Current licensee submissions are based on results produced from small-scale and special effects experiments. There is no information on hydrogen combustion behaviour in a large-scale multi-compartment arrangement similar to those normally found in the containment of a nuclear power reactor. Furthermore, information on the scaling laws, flame acceleration due to obstacles, and combustion in interacting jets is also very limited. In a previous study conducted for the AECB (Project 2.138.1) it was recognized that key assumptions related to hydrogen mixing and burning rate could not be justified. In addition to conducting in-situ tests to determine the hydrogen distribution in the Darlington NGS containment, research in some of the above areas was also recommended.

The results of this project would be used to assess the assumptions in licensee submissions. The knowledge gained in this project would also provide AECB staff with insight into the combustion phenomena and some basis for assessing the effectiveness, claimed by licensees, of the mitigation of the consequences of a hydrogen burn.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (J.W. Blyth)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$7k	$7k	$7k	$21k

Earlier Directly-Related Contracts and Funding:

2.204.1 Pressure Tube Rupture in A Closed Tank - Thermalhydraulic Loadings

It is proposed to reactivate a project (which was proposed in FY 1984/85 but postponed) to investigate the consequences of pressure tube failure on in-core components. The proposal for Phase I deals with the construction and then the use of a test facility to characterize, in a series of separate-effect tests, the thermalhydraulic loadings within a closed tank due to a single fuel channel rupture at operating conditions.

The original proposal of 1984/85 was postponed due to the initiation at that time of a Japanese program addressing the characteristics of pressure tube rupture in a closed tank in which the test facility was vertical. On the basis of recent information currently obtained, AECB staff believes that because of differences in geometry and operating conditions the Japanese tests are not relevant to the issues raised by AECB staff in BMD 85-158. Based on current calculations and experimental results, AECB staff are satisfied that the calandria shell is not at risk; but are not fully satisfied that the consequences on the in-core safety-related components would not hinder the safe shut-down of the reactor. The reasons for this position are given in BMD 85-158.

The findings of this phase of the program will provide information on the degree and extent of the thermalhydraulic loadings within the closed tank.

Proponent	SEDA, CQAD
Technical Advisor/Evaluator	SEDA (C.W. Snoek, J. Tong), CQAD (A. Shalabi)
Project Manager	J.K. Pereira
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$400k	$300k	$750k

Earlier Directly-Related Contracts and Funding:

84.1.10 $82,140

2.206.1 Methodology for Assessment of Training Programs

It is proposed to document methods and techniques which can be used in performing a systematic assessment of the quality and effectiveness of training programs for nuclear plant personnel. The proposed work would involve a survey of programs used for quality control of training in those industries which have an impact on public safety. It would also include a review and evaluation of the findings and specific recommendations for an effective assessment tool for AECB use.

The current AECB audit program is intended to confirm the adequacy of training received by the operating personnel through a formal examination process. To extend this process and ultimately to reduce reliance on examinations, AECB staff are planning to conduct periodic assessments of the quality and effectiveness of the utilities' training programs.

The proposed work would provide guidelines to the AECB staff for conducting assessments of the quality and effectiveness of the utilities' training programs.

Proponent	OCD
Technical Advisor/Evaluator	OCD (G. Turcotte)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$100k	$0k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

2.211.1 Tritium Surface Contact Dosimetry

It is intended to measure the uptake of tritium by mammals (rats, pigs, and humans) following contact of skin with surfaces which are contaminated with elemental tritium (HT), and to study quantitatively the subsequent distribution of organically-bound tritium (OBT) and oxidized HT (HTO) in body tissues and fluids.

An unknown fraction of the total dose from tritium arises from contact with surfaces contaminated with tritium. The only human data on tritium uptake from contact with surfaces contaminated with elemental tritium have been acquired from a few experiments that followed four volunteers in 1965. More recently, work at CRNL has been done with rats, using HT-contaminated planchettes. The present study is proposed because the earlier work on exposures of humans and rats, via contact with tritium-contaminated surfaces, has produced as-yet unexplained and sometimes dissimilar findings. These findings call into question the accuracy of currently-used calculational techniques for evaluating the dose to nuclear power reactor workers, and others, who are occupationally exposed to tritium via contact with surfaces contaminated with tritium (e.g., among workers at tritium removal facilities and tritium lighting manufacturers, and among university researchers).

It is anticipated that the findings of this project will enable AECB staff and licensees to evaluate more accurately the dose and its distribution within the bodies of workers who are subject to exposure to tritium-contaminated surfaces. (It is expected that different aspects of the work will be carried out in Canada, in the United States, and in France. The AECB will be a member of a management group responsible for directing the work. Two external review groups, one of technical experts and the other concerned with ethical aspects, have been constituted to advise the management team. The work is cost-shared among Ontario Hydro, Atomic Energy of Canada Ltd., and AECB. Ontario Hydro is funding more than 50% of the cost of the total project, the upper estimate of which is likely to be approximately $800k.)

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	Ontario Hydro, Research Division
Principal Investigator	Dr. D. Whillans
Category	0

Past	91/92	92/93	93/94	Future	Total
$50k	$50k	$50k	$0k	$0k	$150k

Earlier Directly-Related Contracts and Funding:

2.214.2 Review of Supervisory Functions in Nuclear Power Plants - Phase II

It is proposed to fund a contract which would perform an assessment of the supervisory function in NPPs. Specific reference would be made to training for supervision, the practice of supervisory roles, and the criteria for supervisor performance assessment. The scope of the work would cover first-line supervisors in operations. (This is phase II; the previous project (2.214.1) covered supervisors in maintenance.)

One of the critical components in a program to ensure consistent high quality performance in the workplace is good supervision of the correct type. Consistent occurrence of problems associated with human error may have a source in the style or quality of supervision.

The development of regulatory stances on matters related to human performance in NPPs can only progress adequately when an improved insight into workplace dynamics is achieved. The results of the contract would provide information on the dynamics of the supervisory function.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (L. Innes)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

2.214.1	$54,000

2.216.1 Validation of Positive Void Effect

It is intended to fund a contract which would examine the positive void reactivity effect in CANDU reactors. The study would include a detailed and critical literature search and review of the experimental and theoretical justification for the currently-used values of the void reactivity of the primary heat transport system.

Simulations of reactor power pulses under distorted flux conditions have indicated a proximity to prompt criticality. The AECB, therefore, requires to confirm present estimates of the positive void coefficient. In response to the AECB's requirements (Chernobyl Report), Ontario Hydro has conducted an investigation of the effects of distorted flux/power shapes on shut off rod effectiveness. In Pickering A, the distorted shapes arising from low moderator levels sufficiently reduce the effectiveness of the shut off rods to the extent that prompt criticality is predicted to occur. In addition, the CANDU-3 reactor design is characterized by uni-directional flows in the reactor core. This feature results in a significantly larger void reactivity effect. It is, therefore, important to obtain upper-bound estimates of the void reactivity resulting from a complete blowdown of CANDU reactors.

The results of the contract would provide information which will be used in the safety analyses regarding the potential of prompt criticality to occur in power reactors in some postulated accidents.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (P. Akhtar)
Project Manager	J.K. Pereira
Review Panel	
Contractor	Diamond, D.J.
Principal Investigator	Dr. David J. Diamond
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$55k	$11k	$0k	$0k	$66k

Earlier Directly-Related Contracts and Funding:

2.217.1 Seismic Monitoring East and North of Toronto

It is intended to continue this project which commenced in 1990 with a background noise survey and a selection of five sites for instrumentation and deployment of both analogue and digital seismographs.This year's work would comprise data collection and analysis.

This study was proposed in order to undertake seismic monitoring in the western Lake Ontario-Lake Simcoe-Georgian Bay area. This area was chosen because of the existence, there, of the Pickering and Darlington Nuclear Generating Stations. The objective of the study is to locate, as precisely as possible, microseismic events and ultimately to determine whether or not there is a spatial relationship between earthquakes, irrespective of size, and variously expressed lineaments in the aforementioned area.

It is anticipated that the results of this study will bear directly on improving seismic hazard estimates because reliable locations of microseismic events will aid geoscientists in determining whether or not there are active faults in the vicinity of the generating stations at Darlington and Pickering. If it is shown that there are active faults, then seismologists will be able to effect calculations of seismic wave attenuations from particular locations rather than assuming random sources.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	22
Contractor	Seismican Geophysical Ltd.
Principal Investigator	A. Mohajer
Category	0

Past	91/92	92/93	93/94	Future	Total
$124k	$101k	$81k	$50k	$120k	$476k

Earlier Directly-Related Contracts and Funding:

2.224.1 Emissivity of Zirconium Alloy Surfaces

It is proposed to gather and critically review values for the emissivities of Zircaloy-4 and Zirconium - 2.5% weight Niobium. The project would focus on determining the effect on emissivity of the oxide layer stoichiometry, thickness, phase transition, texture and uniformity, surface temperature, impurity contamination from the fuel, and wavelength.

Heat transfer at high temperatures is credited for lowering the fuel temperature by radiation to the pressure tube. This is affected by the emissivity of the surface. Very little data has been submitted for the conditions of application.

Improved knowledge of high temperature heat transfer would assist in determining what the maximum fuel temperature would be under high temperature transient conditions.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (L.D. Macdonald)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

2.225.1 Estimates of Fission Product Grain-Boundary Release

It is proposed to conduct a study to compare the lower-bound fission product grain-boundary release inventory inferred from spike releases observed in transient annealing experiments with predictions from the computer code ELESIM.

Current estimates of grain-boundary inventory for release of fission products during such times as rewetting are based on models that have been validated only for total release. Recent annealing experiments have shown large spike releases at the start of the anneal indicating that grain-boundary inventories might be much greater than estimates produced by current models. This may be attributed to the possibility that high temperature diffusion coefficients have either not been measured or their accuracy is relatively poor.

Knowledge of fission product grain-boundary inventory will assist in determining source terms during rewetting and periods of thermal and mechanical shocks resulting from depressurization.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (L.D. Macdonald)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

2.226.1 Graphical Post Processor for Scientific Computer Codes

It is proposed to develop a generalized graphical post processor for scientific computer codes. Given geometrical specifications and simulation results from computer codes such as CATHENA, TUF and PATRIC, the processor will schematically present the network being analyzed and graphically code/shade the variation of a specified property around the network. The development of this package should be done on a UNIX (Apollo) system to enhance portability and conform with the current AECB trend. A graphics library such as CA-DISSPLA may have to be acquired to simplify the development of this post processor.

The outputs from complex scientific computer codes tend to be cumbersome and difficult to quickly interpret. Development of the proposed software package may eliminate this problem.

The AECB staff would be able to use this software package to present graphically the result of computer codes, and analyze them in a quick fashion. This facility should expedite the analysis review procedure involving computer code outputs. In addition, the acquisition of a graphic library such as CA-DISSPLA could be utilized for other applications, such as CANDU-3, by the AECB staff.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (K. Amrud)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$45k	$0k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

2.228.1 Acceptance Limit for Steam Generator Tube Loss of Wall Thickness

This project is intended to perform an assessment of acceptance limits used for continued service of steam generator tubes degraded by fretting. The subject plant would be Bruce B nuclear generating station. After having reviewed available inspection records for Bruce B steam generator tubes, the contractor would advise on: a) potential failure mechanisms (including continued fretting, fatigue, environmentally-induced cracking, and overload under design basis conditions); b) criteria for removal of tubes from service; and c) potential limits on the extent of plugging.

Fretting wear, due to flow-induced vibration, is occurring at the U-bend supports in Bruce B steam generators. As a result, many tubes have suffered loss of thickness at the supports of up to 60% in some cases. Based on burst pressure, an acceptance limit has been proposed which theoretically permits wall thickness loss of up to 88%. In view of the potential consequences of simultaneous failure of several tubes, assurance is sought that such an acceptance limit would be conservative for long-term operation.

An independent assessment of steam generator tube degradation at Bruce B NGS would assist AECB staff to determine whether the current acceptance limit for wall thickness loss is conservative. The extensive experience with steam generator tube degradation in the United States would be an invaluable source of information for this project.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (I. Grant)
Project Manager	J.K. Pereira
Review Panel	
Contractor	Dominion Engineering, Inc.
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$24k	$7k	$0k	$0k	$31k

Earlier Directly-Related Contracts and Funding:

2.229.1 Criteria and Tools for Scientific Software Quality Measurements

Not all software used in the nuclear industry needs the rigorous formal verification and reliability testing which are being used on safety critical software. This project is to survey accepted software quality criteria and available tools for measuring software quality, to make recommendations as to the most appropriate criteria and tools for the AECB to use in the evaluation of scientific codes, and to apply these recommended criteria and tools to a specific example.

Currently, the AECB focuses most of the review of scientific modelling software on the mathematical models and their representation of physical reality. However, it has been recognized that the transformation of the mathematical models into software can introduce errors. A method of evaluating the quality of the software is needed. Since this software tends to be large and complex, it is unlikely that manual review techniques would be feasible; automated tools should be investigated. It may also be useful to investigate methods of partitioning and classifying the software so that critical parts can be examined in more detail.

This project will provide AECB staff with a better understanding of the area of software quality measurement and should provide recommendations and a worked example of specific tools and techniques which can be used in practice.

Proponent	SEDE, SEDA
Technical Advisor/Evaluator	SEDE (R. Taylor), SEDA (J.K. Khosla), WID (P. Flavelle)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$15k	$20k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.230.1 Testing for Software Reliability in Computer Systems

This project will build upon the trajectory testing already carried out on safety critical software systems. This research work will have two goals: a) to determine the attributes of a computer system and its external input sequences which will allow statistically valid random testing to be done to specified confidence levels; and b) to explore techniques for obtaining statistically valid reliability figures for existing computer systems.

Experience with critical software systems in aerospace and telecommunication applications indicates that the software contribution to system reliability could be significant. Software reliability is different from hardware reliability because all failures are the result of design errors – software does not "wear out", and an error in one copy of the software will exist in all other copies. Previous and current projects (e.g. 2.127.5) have investigated the current state of the art in software reliability estimation. This project will extend that work by finding specific techniques to make software more amenable to reliability testing and by finding test strategies for software systems which cannot be completely reinitialized on a regular basis.

The results of this study would assist AECB staff in evaluating the reliability of reactor shutdown systems and control systems, when such systems include software.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$40k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

2.127.5	$52,000

2.231.1 Functional Block Languages and Design Methods

This project is to investigate functional block languages and techniques for use in safety–related systems, especially in distributed control systems.

The preliminary design of the CANDU 3 nuclear generating station has proposed the use of a distributed control system which would be programmed using a functional block language. This is a significant departure from a central control system programmed more traditionally in languages such as FORTRAN or Assembler. Functional block languages are supposed to be easier for control engineers to understand and use. The AECB needs assurance that these gains are not offset by any decrease in safety.

This project will provide AECB staff with better understanding of functional block languages, how they are used in distributed control systems and what safety issues arise in their use.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$30k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

2.232.1 Object Oriented Languages and Design Methods

This project is to investigate the potential of object–oriented languages and design methods for real–time safety–critical applications and for simulation software used for nuclear generating station design and evaluation.

Object–oriented techniques are currently having a widespread impact on the software industry. These techniques incorporate the ideas of information hiding modules, simplified and controlled module interfaces, abstract data types, hierarchies of objects with inherited characteristics, and message passing interfaces. Some of these ideas show promise in the areas of software verification, reusability of modules and programmer productivity.

The results of this project will provide AECB staff with the background needed to evaluate the use of object–oriented languages and design methods in safety–critical and simulation systems for nuclear generating stations.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$40k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

2.234.2 Evaluation of Tools and Methods for the Development of Safety Critical Software

It is proposed to investigate the current state of the art in tools and methods for developing and verifying safety critical software and to evaluate Ontario Hydro's tools and methods.

As part of their plan for standards and redesign of the Darlington Shutdown System software, Ontario Hydro will be selecting and/or developing tools and methods. Many tools and methods are currently available, but it is not certain whether they are suitable for the kind of formal specification and verification being planned. It is important for the AECB to be kept abreast of developments in this area so that we can properly assess the use of these tools and methods and understand outputs which may be submitted by licensees.

This project will provide AECB staff with information on what tools are currently available, their characteristics and relative merits plus a comparison with Ontario Hydro's selected tools and methods for the development of the trip computer software and the application of the accepted software development standards.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.127.10	$40,000
2.235.1	$40,000

2.234.3 Review of Prototype Application of Software Standards

It is intended to have an independent review of Ontario Hydro's submissions regarding the prototype application of their software standards. This review will evaluate the complexity and relevance of the selected prototype application, suggest procedures and techniques of reviewing software design and documentation against accepted standards, demonstrate these procedures and techniques on the prototype application, and evaluate Ontario Hydro's interpretation and application of the standards.

Ontario Hydro has proposed that a prototype application be developed as a test of the standards before applying them to a real safety shutdown system. The AECB should make use of this opportunity to develop and practice review and evaluation techniques.

This project will provide AECB staff with valuable insight and examples of how to evaluate Ontario Hydro submissions for software developed according to their new standards.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$15k	$35k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.127.10	$40,000
2.234.1	$40,000
2.234.2	$50,000

2.234.4 Review of Trip Computer System Specifications

It is proposed to have an independent review of system requirement specification documents for the Darlington shutdown systems (SDS1 and SDS2) to help determine whether the systems have been completely and correctly specified in light of the accepted standards and best current specification techniques.

The first step in the redesign of the Darlington shutdown systems will be a revision of the system requirement specifications. It is recognized that the existing specifications are too ambiguous and inconsistent to provide a strong foundation for the redesign. Consequently, it is expected that Ontario Hydro will submit a new system requirement specification which will have to be reviewed for completeness, correctness, conformance to standards and safety.

This project will provide AECB staff with independent and expert advice concerning the acceptability of the system requirement specification.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.127.10	$40,000
2.234.1	$40,000
2.234.2	$50,000
2.234.3	$50,000

2.234.5 Review of Trip Computer Redesign

It is proposed to have an independent review of Ontario Hydro's submissions regarding the redesign of the Darlington NGS shutdown systems (SDS1 and SDS2) to determine whether the documents properly follow the accepted standards and to determine the safety, maintainability and verifiability of the design.

Considering the special conditions related to the shutdown systems software in the Darlington Operating License 13/90, it is extremely important that the redesigned software be reviewed thoroughly and fairly. For this reason, it is essential that independent software expertise be brought into the review process. The current intent is to completely review the higher level documentation (Requirement Specifications and Preliminary Design) and to conduct a guided inspection/walkthrough/audit of selected parts of the detailed design and code.

This project will enhance the quality and credibility of AECB's review of the redesigned Darlington shutdown system software.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$0k	$100k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

2.127.10	$40,000
2.234.1	$40,000
2.234.2	$50,000
2.234.3	$50,000
2.234.4	$50,000

2.234.6 Review of Trip Computer Testing

It is proposed to have an independent review of: 1. the new design of the shutdown systems to determine if statistically valid random testing is feasible within an acceptable time period, 2. Ontario Hydro submissions regarding deterministic testing, and 3. Ontario Hydro submissions regarding random testing.

The testing of the redesigned shutdown systems is an important component of assuring their safety and reliability. The AECB has stated that safety system software must be designed for testability and verifiability, and that both deterministic and random testing must be done.

This project will provide AECB staff with independent and expert advice on the design quality and the acceptability of Ontario Hydro's test reports.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R. Taylor)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$0k	$50k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.127.10	$40,000
2.234.1	$40,000
2.234.2	$50,000
2.234.3	$50,000
2.234.4	$50,000
2.234.5	$100,000

2.235.1 Processes in Radioactivity Removal

In order to gain knowledge on the state of the art in engineered processes in radioactivity removal prior to releases from nuclear power plants, it is proposed to review critically these processes, including those using filters with media other than charcoal (e.g. silver zeolite, stainless steel, sand, etc.), or other processes such as photochemical and venturi scrubbing techniques.

Technical and procedural problems involving the use of charcoal filters in the Emergency Filtered Air Discharge systems have been studied in a previous research project (2.187.1). During this study, it has become evident that a comparative review of alternative methods would assist Board staff in assessing radioactivity removal techniques.

The results of this work will provide the Board's staff with the knowledge necessary to make informed licensing decisions.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (L. Truong), PRDB (J. Ricard), PRDA (U. Nurmsoo), REPD (S.H. Ching)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

2.187.1	$50,000
2.187.2	$27,000

2.236.1 Diagnostic Skills and Mental Model Development

It is intended to fund a literature review to produce a review report for the AECB on the extent to which systematic procedures can be applied to aid in the formation of mental models for use in supervisory control in process industries, and in the use of these models for system diagnosis in nuclear power plants.

During plant events that are beyond the design basis, operators are required to diagnose the problem, and to make decisions on corrective actions. These cognitive activities are thought to be aided by the operator's mental model of the ideal plant, compared to his model of the upset plant. An understanding of how far these models can be shaped through intentional strategies would make a significant contribution to safe plant operation.

Safe and effective plant control through control room operator performance may depend more on diagnosis than on compensation and recovery activities. Although the relative importance of these activities is debated, they clearly are linked, and are both involved in most operator tasks. The development of appropriate regulatory positions will be aided through achieving a better understanding of the individual differences in diagnostic processes, and reducing the degree of variability in them.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (L. Innes), OCD (R. Thomas)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$5k	$25k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

2.237.1 Assessment of Psychological Capacities Requirements

It is proposed to fund a project which would review the professional training and psychological literature on needs analysis for continuing knowledge and skills development commensurate with advancement through a technical career. The report would detail findings with relevance to operator continuing training and operator requalification needs in the nuclear industry.

Individual operator competence levels and competence requirements are established for entry level positions at each grade of the operator family. The development of these skills and the acquisition of new skills and abilities with progression through a career is not well defined. It is a pre-requisite to the relicensing of mature operators that it is known what skills and abilities they must have to function effectively in their role. This is not known presently in sufficient clarity to allow suitable regulation development.

Continuing high levels of operator performance on the job throughout a career is a vital component of nuclear power plant safety. The maintenance of these performance levels depends in large measure on the development by operators of appropriate new knowledge and skills as they progress through increasing responsibility levels. Regulatory review to establish that operators are being equipped properly to do the job is a requirement of mature operator re-licensing.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (L. Innes), OCD (R. Thomas)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.238.1 Review of Computer Codes MODTURC and PHOENICS

It is intended to fund a contract to review the computer codes MODTURC and PHOENICS in order to ensure that their mathematical formulation of the physical phenomena, numerical representation and the solution are valid. These reviews would also include an examination of the available information on the verification and validation of the codes. In addition, a sensitivity analysis study to demonstrate the effect of important parameters in each of these codes and a code-to-code comparison for a given problem(s) would be required.

MODTURC and PHOENICS are complex three dimensional codes which have been used to simulate the behaviour of the moderator system inside the calandria in the safety analyses submitted by Ontario Hydro and NB Power respectively. The results of these codes help define the moderator temperature control set-point (taking into account the minimum available subcooling margin) in order to ensure that the moderator remains an effective heat sink under accident conditions. In view of staff limitations in the Computer Code Review Group, it is felt that the services of a competent consultant would be highly desirable.

A timely review of these codes will help AECB staff gain confidence in the capability of these codes to predict moderator system behaviour under normal as well as accident conditions and thus confirm the acceptability of the safety analysis.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (V. Tang)
Project Manager	M. Mortimer
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$24k	$30k	$0k	$0k	$54k

Earlier Directly-Related Contracts and Funding:

2.239.1 Installation and Training in the Use of Aerosol Computer Codes

The services of AECL staff are required to install certain aerosol computer codes on our computers and to provide training to AECB staff to enable them to run these codes efficiently. This would also include consultation after the initial installation. Such services would be required on an 'as needed' basis.

Experience in the use of licensees' computer codes has indicated that an excessive amount of time could be spent by AECB staff in getting some of the codes to run on our computers. AECL staff familiar with these codes would assist us in reducing the start-up time and in running them more efficiently.

The review of aerosol computer codes is required as part of our safety assessment of the CANDU-6 and CANDU-3 reactors.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Truong)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$15k	$0k	$0k	$15k

Earlier Directly-Related Contracts and Funding:

2.241.2 Technical Review of the CANDU-3 PSA (Phase 2)

It is proposed to fund a contract to review the CANDU-3 Probabilistic Safety Assessment to identify major safety concerns. This phase would provide a more detailed examination of the ranked issues, following the completion of Phase 1.

To date, the AECB has had limited resources to devote to review of the CANDU-3 PSA. Beginning such a review is desirable.

The results of the contract would be used in the continuing review of the CANDU-3 PSA.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (K. Asmis)
Project Manager	M. Mortimer
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$65k	$0k	$0k	$65k

Earlier Directly-Related Contracts and Funding:

2.219.1	$50,000
2.219.2	$22,000

2.242.2 Stratigraphy in Paleozoic Rocks in the CMBBZ

It is proposed to make complete and detailed descriptions of the stratigraphic sections of Paleozoic rocks exposed along the northward projection of the Niagara-Pickering Linear Zone/Central Metasedimentary Belt Boundary Zone (NPLZ/CMBBZ), which passes directly beneath the Pickeirng NGS.

This work is proposed to: a) document the characteristics of all of the Paleozoic stratigraphic units in the area and b) confirm or refute the strong suggestion from the 1991 field work, completed by AECB staff, that there are vertical displacements of on the order of 30 m across at least two major lineaments which constitute the NPLZ/CMBBZ.

It is anticipated that this work will show that there is evidence of bedrock faulting cutting the youngest rocks exposed along the projection of the NPLZ/CMBBZ. Should this anticipation be fulfilled, it will have direct implications for the assessment of seismic hazard in the vicinity of the Darlington and Pickering Nuclear Power Plants.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Sanford, B.
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

2.242.1 $3,500

2.243.1 Marine Geophysics in Western Lake Ontario

It is proposed to undertake a marine geophysical investigation in Lakes Ontario, Simcoe and Scugog. The survey is to include seismic penetration deep into the bedrock,echo-sounding, shallow seismic penetration into the lake-bottom sediments and into the underlying Paleozoic bedrock surface, side-scan sonar and magnetics. Staff of the Atlantic Geosciences Center and the Terrain Sciences Division of the GSC have expressed an interest in participating in this project, though no commitments have been made.

This work is proposed to determine if major geophysically expressed lineaments in the immediate vicinity of the Darlington and Pickering NGS are potentially seismically active. Information on their characteristics of these lineaments appear in AECB INFO-0342 and in a paper presented to the Canadian Geotechnical Conference. A single echo sounding traverse, conducted in June 1990 across one of the lineaments (NPLZ) in Frenchman's Bay (on which is situated the Pickering NGS), showed a change in elevation of the lake bottom.

It is anticipated that this study will indicate whether the lineaments have, or do not have, topographic expression in the unconsolidated sediments on the bottoms of the aforementioned lakes. If there is abrupt topographic expression, this will imply that the potential for seismic activity is high. If such is the case, an analysis will be needed of the length of, and the vertical elevations across, the topographically expressed segments to estimate the magnitudes of previous earthquakes. This project has the potential for identifying crustally-derived, neotectonic movements. Depending on the results of this first phase, further similar investigations in subsequent years might be called for.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Geological Survey of Canada
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$100k	$0k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

2.217.1	$413,000
2.222.1	$15,000
2.240.1	$33,000

2.244.1 Elevation Determinations of Stratigraphic Contacts in the CMBBZ

It is proposed to measure the elevations of the contacts of different stratigraphic units along the NPLZ/CMBBZ, most notably the contact between the Gull River Limestone and the overlying Bobcaygeon Formation which is exposed at several different outcrops.

This work is proposed because there is the strong suggestion of vertical displacements of stratigraphic markers due to faulting. However,the contour interval on the existing topographic maps in the area of interest is 50 ft (15m) which is too large to determine the amount of stratigraphic offset, if any, across major lineaments.

It is anticipated that this work will, in conjunction with project 2.242.2, show that there is evidence of bedrock faulting cutting the youngest rocks exposed along the projection of the NPLZ/CMBBZ and will reveal the precise amount of vertical displacement. As indicated for project 2.242.2, the results of this study will have direct implications for the assessment of seismic hazard in the vicinity of the Darlington and Pickering Nuclear Power Plants.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

2.242.1	$3,500
2.242.2	$40,000

2.245.1 Acceptability of Spacer-Pad Wear Allowance

It is proposed to carry out an analytical study to examine the effect of spacer pad wear allowance on subchannel thermal hydraulics.

Fuel from Darlington Unit 2 had spacer-pad wear such that the outer elements were bowed inwards up to 3 mm. High burnup bundles from Bruce have had outer-element bows of up to 2 mm. The bundles appear to be collapsing under the axial thermal hydraulic load as their spacer pads wear. The Fuel Design Manuals state that the spacer pad wear allowance is designed to leave a spacing, between the elements, of 0.64 mm for heat transfer. However, justification for this heat transfer predates current critical heat flux (CHF) correlations. A subchannel analysis could estimate the effect of this bundle diameter reduction flow bypassing and the CHF.

Knowledge of the effect of pad wear on CHF is required to determine the acceptability of the wear allowances.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (Macdonald)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

2.246.1 The Behaviour of Zirconium Alloys in Reducing Environments

It is proposed to measure the oxidation kinetics and heat balances encountered with Zircaloy-4 and zirconium-2.5wt% niobium at high temperatures under steam-starvation conditions. The study should also measure the effect of hydrogen under such conditions on the high temperature creep behaviour of the two alloys.

Current safety analyses claim that steam-starved conditions exist during severe accidents. Oxide layers on Zircaloy-4 and zirconium-2.5wt% niobium dissolve under such conditions and the uptake of hydrogen increases. Hydrogen may embrittle the zirconium alloys during cooldown and increase deformation by lowering the phase change temperature at high temperatures.

Knowledge of the effects of steam-starved conditions will help determine whether current analyses adequately describe such behaviour.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (MacDonald), CQAD (Shalabi)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$80k	$0k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

2.247.1 Load Factors for the Design of CANDU Concrete Structures

It is proposed to review the current load factors and load combinations used in the design of concrete containment structures and safety related structures in CANDU nuclear power plants. Further, the margin of safety inherent through the use of these factors is to be assessed using a probabilistic approach. Recommendations are sought for revision of load factors if needed because of the variability of loads, to provide an acceptable and relatively uniform degree of safety in the design of structural members under different load combinations. The same approach is to be used to derive appropriate load factors for application to existing structures.

The current load factors used in the design of containment and safety related structures were taken from the National Building Code of Canada. These factors were derived to be used in the design of building structures subjected to "normal" dead and live loads. CANDU nuclear power plants cannot be classified as "regular" buildings and are subjected to very unusual loads. This should be reflected in the use of appropriate load factors and load combinations that reflect the more serious consequences of failure.

The study will enable a clear distinction between ultimate limit state design which is related to safety and serviceability limit state design which is related to vibration and/or cracking of concrete. The "updated" load factors will be considered for inclusion in revisions of the CSA-N287.3 (containments) and CSA-N291 (safety related structures) standards.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (C.Pilette)
Project Manager	J.K. Pereira
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.248.1 Seismic Analysis of the Pickering Pressure Relief Duct

It is proposed to conduct a dynamic analysis of the Pickering Generating Station pressure relief duct to determine the seismic response of the structure.

The study will comprise analytical simulations completed in accord with the requirements of CSA Standard N289 (i.e., assuming elastic behaviour) of the capacity of the pressure relief duct when subject to "severe ground motion" load. These analyses will include consideration of material non-linearities such as cracking of the concrete and yielding of the reinforcing bars. The results of the study will give a measure of a measure of the likely "level of damage" as a function of "ground motion intensity". Such information is needed to afford benchmark data for use in assessment of submissions from Ontario Hydro on a seismic safety margin review being completed for Pickering Generating Station.

Results from this research project will be used to assess the adequacy of the safety case for the Pickering pressure relief duct under design basis earthquake loading.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (C. Pilette)
Project Manager	J.K. Pereira
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.249.1 Compliance with Bundle Power and Channel Power Limits

It is proposed to conduct a review of the computer codes which are used to demonstrate compliance with bundle power and channel power limits in various CANDU reactors. The study would include a review of models and input data used in these codes. It would also determine if comparisons with measurements are supported by an adequate data base and whether they remain valid for reactor operation with distorted flux shapes.

Compliance with bundle and channel power limits specified in OP & P documents is demonstrated through computer simulations, especially in reactors where boiling occurs in channels. Therefore, it is important to establish the accuracy of these simulations. Furthermore, the reactor models and input data used in these simulations have varying degrees of detail at various sites. The impact of these differences on accuracy of the calculations is not clear.

The results of the study would be used in assessing licensee compliance with OP & P bundle power and channel power limits.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (P. Akhtar)
Project Manager	J.K. Pereira
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.250.1 Pressure Tube Inspection Capability

A project is proposed to study defects, found by inspection, caused by the degradation of pressure tubes. The contractor would obtain available date from pressure tube history dockets for the 'in-service inspection' and 'periodic inspection' programs to evaluate and compare to the accuracy needed to predict rates of degradation.

Currently, all reactors in service have some flaws in their pressure tubes. Continuing operation with degraded pressure tubes requires a database of flaws, detected by in-reactor non-destructive examination techniques, to enable characterization of the extent and rate of degration.

This database would assist in establishing a practical program of inspection and would help quantify the risks associated in dispositioning tubes with defects.

Proponent	CAQD
Technical Advisor/Evaluator	CQAD (A. Shalabi)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

2.252.1 Training for Troubleshooting Skills

It is proposed to do a review of literature to determine the state-of-the-art training for troubleshooting skills. In addition, a survey of industry and the defence sector for current practice in training for troubleshooting skills is required. Finally, a survey of current troubleshooting training in the nuclear industry should be completed and a comparison made with industry/defence practices.

Part of the work performed by operations personnel and maintenance personnel at NPPs involves occasional troubleshooting of equipment/system failure. It is known that there are several different ways in which troubleshooting may be attempted, some of which are more applicable to certain situations than are others. Little is known about the type of training for troubleshooting skills given to personnel who must perform troubleshooting functions in NPPs.

The results of this project will be used to establish acceptable training practice for troubleshooting skills, and to assess training programs in the nuclear industry in terms of such training practice.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (F. Harrison)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

REGULATORY RESEARCH AND SUPPORT PROGRAM 1992/93

2.253.1 Information System Design and Its Impact on User Mental Workload: An Analysis of Current Work

It is proposed to explore and to assess any current research activities and findings as related to the limits in the amount of information presented at any one time to a potential user when designing computer-based information systems. Further, it is proposed to examine how the information load can affect the user's mental workload, especially when performing under stress.

AECB staff will be required to evaluate computer-based information systems to be used by Unit First Operators. Presently, there are no design criteria or even guidelines concerning the above topic which can be used by AECB staff in assessing the adequacy of such systems.

The results of this project would lead to the potential development of a guideline which could then be used by AECB staff in assessing the information load placed on Unit First Operators while using computer-based information systems.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (R. Joly)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$15k	$0k	$0k	$15k

Earlier Directly-Related Contracts and Funding:

2.254.1 Uncertainties in Heavy Gas Dispersion

It is proposed to perform a literature survey of available models and studies related to dispersion of heavy gases under weather and topographical conditions typical of those found around the Bruce Heavy Water Plant (BHWP) such as bluffs and tree canopies. Based on the available information, an order-of-magnitude estimate will be carried out to provide an appreciation of the potential effects due to these parameters.

Current dispersion calculations for BHWP Hydrogen Sulphide concentration do not take into account the above-mentioned effects. There is a possibility that, under special weather conditions, the heavy gas may accumulate near the bluff and high gas concentration may result from intermittent flushing of heavy gas which has previously been trapped in tree canopies.

The results of this work will assist the AECB staff in the review of the BHWP licensing submissions.

Proponent	SEDA
Technical Advisor/Evaluator	SEDA (L. Truong), PRDB (C. McDermott)
Project Manager	M. Mortimer
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

2.255.1 Formal Methods in the Development of Computerized, Real-Time, Safety-Critical Control Systems

It is intended that an international study team investigate actual uses of Formal Methods in the development of computerized, real-time, safety-critical control systems. This investigation would use a conventional Case Study approach. Data would be collected through analysis of the relevant literature, structured interviews with project teams and managers, and a series of industry surveys.

It has been recognized that the use of Formal Methods is an important part of the development of reliable systems. Formal Methods are required by a number of recent software development standards, including Ontario Hydro's high level standard for software engineering of safety critical systems, David Parnas' suggested software development standard and the British MoD standard 00-55. This study will investigate what formal methods have actually been used in industry, and what the effect of using formal methods has been such as the perceived increase in trustworthiness and the cost impact. It should be noted that this proposal is to support the Canadian participation in an international study. The AECB cost would be small compared with the overall value of the complete project since other funding agencies will be participating.

The results of this study will assist AECB staff in understanding the advantages and disadvantages of the use of Formal Methods in safety critical software development. It will provide concrete data on real applications of Formal Methods which can be used to support the AECB position regarding safety critical software in nuclear power plants.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (R.P. Taylor)
Project Manager	Y. Akl
Review Panel	
Contractor	Odyssey Research Associates
Principal Investigator	Dr. D. Craigen
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$25k	$0k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

2.257.1 Modification of the SECT Computer Program

It is intended to adapt the current personal computer (PC) version of the Significant Event Coding Tree Program (SECT) so that it can be used to study significant events that have occurred at different CANDU stations. This adapted and fully documented SECT-PC program will be installed and made operational on the AECB computer system. In addition, results of sample runs using CANDU data will be provided.

SECT was originally developed by the AECB for mini-computers. It was later modified extensively by an international group to run on personal computers. The current international version is user-friendly and contains several useful features, but it was tailored for reactors other than CANDUs.

The resulting tool will enable AECB staff to analyse significant events more readily and more effectively. Potentially, it could be used to verify licensing submissions involving fault tree analysis.

Proponent	PRDB
Technical Advisor/Evaluator	PRDB (H. Ragheb)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$25k	$7k	$0k	$0k	$32k

Earlier Directly-Related Contracts and Funding:

2.258.1 Definition of Systems in Nuclear Power Plants

It is proposed to perform an alternative partitioning of a nuclear power plant into systems and sub-systems. Each system or sub-system would be defined and clearly identified by its objective, by its physical and functional boundaries, and by its interactions with its environment. The proposed study will describe the methodology used and the difficulties encountered during the exercise. Also, it will present examples of problems caused by current system partitioning methods, and discuss the potential advantages of the new approach in resolving these problems.

AECB staff has often been unable to fully verify the accuracy of licensing submission (reliability analyses and probabilistic safety assessments) because of the lack of clear and consistent definitions of the systems involved. In many cases, system boundaries as defined by the designer (USI numbers) do not correspond to functional boundaries. This lack of correspondence has potential negative effects on operational reliability, for example through maintenance procedures, as well as on safety assessments.

The results of this pilot study will demonstrate some of the benefits and drawbacks of using the systems approach on defining system boundaries. This will help AECB staff in deciding whether the introduction of this concept as a licensing requirement would be warranted.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (K. Lafrenière), PRDA, PRDB
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.259.1 Review of the Bruce-A Fuelling Machine System

It is proposed to carry out a review of Ontario Hydro submissions on proposed hardware and software changes to the Bruce-A fuelling machine systems.

The information to be reviewed (with emphasis on the safety implications) includes design manuals, wiring diagrams, a reliability analysis, a software hazard analysis, the software quality assurance program, documentation of software changes, and the results of an independent software review.

Following the January 1990 channel C08 incident, the AECB requested a formalized action plan for improvements to the fuelling machine system, and requested the documentation described above for review. This is an extensive computerized system and we require consulting support to augment our in-house effort. The results of this project will assist AECB staff in its assessment of the Ontario Hydro submissions.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (L. Tougas), PRDB
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

2.260.1 Review of Reactor Regulating System Software

It is proposed to carry out a review of the reactor regulating system software at the Bruce-A NGS, including a summary of the roles and designs of the various programs making up the computerized system. In addition, design changes, Significant Event Reports, and follow-up reports related to incidents or problems contributed to or caused by the reactor regulating system software would be reviewed. Recommendations on the impacts of previously implemented and proposed changes on the reliability and safety of the reactor regulating system would be given.

A review of significant events has identified several events in which software design errors or inadequate software changes were either the cause or a contributing factor. Although the regulating system has traditionally received less AECB scrutiny than special safety systems, the events have indicated the potential importance to safety of the reactor regulating system software.

The results of this review will assist AECB staff in establishing appropriate recommendations for the planned rehabilitation of these systems. They would also provide a basis for deciding whether more detailed reviews of these systems at Bruce NGS and at other CANDU stations are warranted.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (L. Tougas), PRDB
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.261.1 Fast Bus Transfer Schemes at CANDU Power Stations

It is proposed to analyse the performance of the fast bus transfer schemes used at CANDU power stations. Computer models are to be developed for the required simulation studies.

Inadequate bus transfer schemes could damage electrical equipment such as main coolant pump motors and transformers. The USNRC has performed a worldwide survey recently on equipment damage caused by inadequacies in fast bus transfer arrangements. Ontario Hydro has performed a simulation study for the Darlington transfer scheme. Findings from that study led to a change in the reconnecting voltage specified for the main coolant pump motors. However, subsequent studies completed by Ontario Hydro have yielded contradictory results. These latter results suggest that the implemented change was not essential. There is a need for further analyses of the likely performance of installed fast bus transfer schemes.

The results of this study would help AECB staff to assess the adequacy of the design of fast transfer schemes in existing CANDU power stations and enable AECB staff to more effectively evaluate the design of transfer schemes at future nuclear power stations.

Proponent	SEDE
Technical Advisor/Evaluator	SEDE (T. Leung)
Project Manager	J.K. Pereira
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

3.101.2 Demonstration of the Feasibility of Directly Dating Quartz - Phase II

It is proposed to obtain samples of rock, the ages of which lie for the most part within the range of from about 400 million years to 1,000 million years, and date them using the electron-spin resonance (ESR) dating technique developed in phase 1.

This study is proposed in order to establish conclusively that a linear relationship exists between the strength of the ESR signal and the age of the quartz. The existence of this possible relationship was suggested from the previous study in which samples ranging in age from 100 thousand to 400 million years and from 1 billion to 1.4 billion years were evaluated. However, there is a 600 million year data gap between those two groupings and this has to be filled in to confirm or deny the relationship.

It is anticipated that the results of this study, if they establish that the linear relationship exists, will be useful for determining the age of last movements along faults. This will, in turn, provide a means for determining whether or not an area is tectonically stable which, of course, has implications for seismic hazard and seismic risk estimates relevant to nuclear facilities. The ages of interest in this application are much younger than those to be tested during this study. However, it is necessary to establish reliably that a linear relationship exists over the entire age range before the method can be used as a trustworthy indicator of recent tectonic stability.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	16
Contractor	Odom, A.L.
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

3.101.1	$50,000

3.103.1 Absorbed Fraction of Ingested Uranium in Humans

It is intended to determine the absorbed fraction of ingested dietary uranium (from both food and drinking water) in persons living near certain nuclear facilities, by measuring the content of uranium in their diet and in their fecal and urinary excretions.

The currently used annual limit on intake (ALI) for uranium, by ingestion, is derived using a value of 0.05 for the absorbed fraction of ingested uranium. This value is known to have a number of uncertainties, and more work should be done to improve its accuracy.

The results of the study are expected to improve the value for the absorbed fraction and hence the estimate of the ALI (oral) for uranium. (This project is being done jointly with the Bureau of Radiation and Medical Devices of NHW. Their contribution consists of the laboratory analyses to be undertaken in this project.)

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (C. Pomroy, M. Measures)
Project Manager	K.P. Ho
Review Panel	04
Contractor	Bureau of Radiation and Medical Devices
Principal Investigator	Dr. Bliss Tracy and Dr. Maria Limson-Zamora
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$60k	$0k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

3.111.1 Evaluation of Data and Models on Uranium Metabolism - Europe

It is intended to complete the compilation of currently known data regarding the intake, transfer (among organs), retention, and excretion rates of uranium in uranium workers, with a view to: testing currently available metabolic and dosimetric models with different data sets; comparing computed excretion patterns to the observed ones; and determining which model describes best the known data (or how a selected model should be modified to fit the observed data).

Several models for uranium metabolism exist at present, but none seems to describe realistically uranium transfer, retention, and excretion rates in humans. Since individual doses from occupational uranium intake are generally determined from the interpretation of bioassay data (urinalysis), the AECB Radiation and Environmental Protection Division needs to identify and acquire a reliable tool for calculating doses in the case of exposure to uranium compounds.

It is anticipated that the study will assist in identifying and in providing AECB staff with a state-of-the-art metabolic and dosimetric model for uranium intake. This model will be compared to the one derived in 3.111.2.

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	Centre d'Etudes Nucléaires de Fontenay-aux-Roses
Principal Investigator	Dr. P.G. Beau
Category	0

Past	91/92	92/93	93/94	Future	Total
$28k	$9k	$2k	$0k	$0k	$39k

Earlier Directly-Related Contracts and Funding:

3.111.2 Evaluation of Data and Models on Uranium Metabolism - North America

It is intended to test and validate currently available metabolic and dosimetric models for uranium. This is being done with data, obtained from animal experiments and human exposure, that have been, or will be, critically reviewed. Computed excretion patterns will be compared with observed ones. The best predictive models will be identified and improvements to them will be made, if necessary.

Several models for uranium metabolism exist at present, but none seems to describe realistically uranium transfer, retention, and excretion rates in humans. Since individual doses from occupational uranium intake are generally determined from the interpretation of bioassay data (urinalysis), the AECB's Radiation and Environmental Protection Division needs to identify and acquire a reliable tool for calculating doses in the case of exposure to uranium compounds.

It is anticipated that the study will assist in identifying and in providing AECB staff with the state-of-the-art metabolic and dosimetric models for uranium intake. Information obtained under 3.111.1 will be used to modify and verify the model using complete data sets obtained from occupationally exposed uranium workers.

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	Radiation Surveillance Associates, Inc.
Principal Investigator	Dr. M.E. Wrenn
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$68k	$68k	$0k	$0k	$136k

Earlier Directly-Related Contracts and Funding:

3.111.1	$39,000

3.121.3 BIOMOVS II - International Assessment of Biosphere Models

It is intended to participate in and partially fund the second phase of BIOMOVS (BIOspheric MOdel Validation Study) which is an international co-operative effort to test biospheric models designed to calculate the environmental transfer and bioaccumulation of radionuclides and other trace substances. BIOMOVS II is being organized and jointly funded by the Swedish Radiation Protection Institute (SSI), the Empressa Nacional de Residuos Radiactivos S A (ENRESA) and the Centro de Investigaciones Energeticas Medioambientales y Tecnologicas (CIEMAT) of Spain, Atomic Energy of Canada Limited (AECL) Research Company and the Atomic Energy Control Board (AECB) of Canada.

The first phase of BIOMOVS (3.121.1), which was mainly an international intercomparison of environmental assessment models and their predictions, was initiated in 1986 with the participation of 14 organizations from 12 countries including Canada, and was completed in 1990. At the final meeting of BIOMOVS, the participants concluded that a continuation of the effort, with additional studies and funding support, would be useful. BIOMOVS II will continue studying a number of issues that were identified in the first phase of the study to be of special importance in assessing the reliability and validity of environmental transfer modelling. The emphasis will be placed on scenario development and model evaluation, uncertainties in the predictions of assessment models and mathematical aspects of assessment models. The study will involve modellers and other scientists working in the field of safety assessment and other related disciplines, as well as experimentalists performing laboratory or field studies in these areas. The results may be used in conjunction with other model-testing studies.

Involvement of AECB and Canadian experts in this program is important in ensuring the credibility of modelling activities in Canada and in regulatory decisions based on such modelling. The results of the study will provide the AECB with a greater understanding of the validity and reliability of biosphere models used to support licensing assessments of environmental impacts from nuclear facilities.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$100k	$120k	$110k	$220k	$550k

Earlier Directly-Related Contracts and Funding:

3.121.1	$154,000
3.121.2	$5,000

3.123.1 Influence of Macrophages on Dissolution of Uranium Compounds

It is the purpose of this work to study in the laboratory, the influence of macrophages, oxygen and carbon dioxide on the in vitro dissolution rates of uranium compounds, as a function of the chemical forms and particle sizes of these compounds. (Macrophages are specialized cells whose function is to destroy bacteria and foreign materials that enter an organism.) The results of the in vitro solubility tests will be compared to clearance rates of the same uranium compounds deposited in the tracheal lobe of the respiratory system of sheep.

Experimental data on the biokinetics of uranium in man are not consistently compatible with in vitro solubility rates (of the same compounds) which are widely used in current dosimetric models. Recent information from laboratories of the French Atomic Energy Commission (Service of Experimental Pathology) indicates that the solubility rate of uranium compounds is significantly enhanced by the presence of macrophages in, and by the addition of oxygen to, simulated lung fluid. The solubility rates observed under these experimental conditions seem to represent more accurately the clearance rates observed in man. The solubility rate of radioactive material is an important parameter of metabolic and dosimetric models, and it is necessary that AECB staff know, and use, the most realistic and accurate parameters in these models, whether for determining regulatory exposure limits or for deriving bioassay guidelines for accidental or routine radiation exposures. The present study is designed on the basis of the procedures developed and tested by the French Atomic Energy Commission and on the use of sheep as an experimental animal. It has been shown that the respiratory tract of sheep, with its tracheal lobe that branches directly from the trachea, lends itself to localized deposition of test materials without impairing significantly respiratory functions. However, these procedures would be used in parallel with procedures developed in previous AECB studies, with a view to correlating data of past and future solubility tests.

It is anticipated that the results of the study will provide the AECB with realistic solubility parameters to be used for the determination of bioassay guidelines, and for exposure and dose calculations. It is also anticipated that the results will be used to develop a laboratory procedure to determine, accurately and economically, solubility rates and lung clearance rates of uranium compounds.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	Centre hospitalier universitaire de Sherbrooke
Principal Investigator	Dr. R. Bégin
Category	0

Past	91/92	92/93	93/94	Future	Total
$114k	$6k	$14k	$0k	$0k	$134k

Earlier Directly-Related Contracts and Funding:

3.123.2 Macrophage Influence on Dissolution of Uranium Compounds - II

It is intended to study macrophage influence on dissolution of uranium compounds. This project is the follow-on work to the earlier project 3.123.1 'Influence of Macrophages on Dissolution of Uranium Compounds' which consisted of two preliminary studies and a feasibility study. The current project will compare the rates at which uranium, thorium, radium, and lead from dust samples clear the trachial lobe of sheep, with the dissolution rates of the same radioisotope samples in simulated lung fluid in which macrophages, oxygen, and carbon dioxide are independently absent or present.

Experimental data on the biokinetics of uranium in man are not consistently compatible with in vitro solubility rates (of the same compounds) which are widely used in current dosimetric models. Recent information from laboratories of the French Atomic Energy Commission (Service of Experimental Pathology) indicates that the solubility rate of uranium compounds is significantly enhanced by the presence of macrophages in, and by the addition of oxygen to, simulated lung fluid. The solubility rates observed under these experimental conditions seem to represent more accurately the clearance rates observed in man. The solubility rate of radioactive material is an important parameter of metabolic and dosimetric models, and it is necessary that AECB staff know, and use, the most realistic and accurate parameters in these models, whether for determining regulatory exposure limits or for deriving bioassay guidelines for accidental or routine radiation exposures. The present study is designed on the basis of the procedures developed and tested by the French Atomic Energy Commission and on the use of sheep as an experimental animal. It has been shown that the respiratory tract of sheep, with its tracheal lobe that branches directly from the trachea, lends itself to localized deposition of test materials without impairing significantly respiratory functions. However, these procedures would be used in parallel with procedures developed in previous AECB studies, with a view to correlating data of past and future solubility tests.

It is anticipated that the results of the study will provide the AECB with realistic solubility parameters to be used for the determination of bioassay guidelines, and for exposure and dose calculations. It is also anticipated that the results will be used to develop a laboratory procedure to determine, accurately and economically, solubility rates and lung clearance rates of uranium compounds.

Proponent	HES, REPD
Technical Advisor/Evaluator	REPD (F. Horvath, M. Measures)
Project Manager	E. Rabin
Review Panel	
Contractor	Centre hospitalier universitaire de Sherbrooke
Principal Investigator	Dr. R. Bégin
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$60k	$0k	$120k

Earlier Directly-Related Contracts and Funding:

3.123.1 $126,000

3.134.1 RBE from a Microdosimetric Approach

It is proposed to conduct a critical review of the literature on the state-of-the-art of the relationship between radiation-matter interactions in cell components and the Relative Biological Effectiveness (RBE) of high linear energy transfer radiation with an emphasis on the effect of alpha radiation on the cells of human bronchial epithelium.

In spite of elaborate laboratory experiments and epidemiological studies, risk coefficients for specific types of radiation are determined with uncertainties, at best, of the same magnitude as the variable being determined; in some cases, uncertainties are as large as one order of magnitude. An important parameter in establishing risk coefficients is the RBE of the type of radiation under consideration. Microdosimetry has been a powerful tool in the study of radiation-matter interaction in living cells, and of the changes induced in cell components at the molecular level. The continuous refinement of microdosimetric models has led progressively to a better understanding of radiation effects in the case of radionuclides incorporated in cell components, as well as that of exposure to external radiation. It seems, at present, that convergent efforts in epidemiology, animal experiments and microdosimetry are necessary to determine the RBE, and therefore the risk, more accurately. At a time when regulatory limits on exposure to radon daughters tend to be revised downward, it is important to understand, as well as possible, the mechanisms that lead from irradiation of lung tissues by alpha particles to malignancies in order to support regulatory decisions.

It is anticipated that a critical review of the state-of-the-art research on the relationship between radiation-matter interaction and biological modification at the nucleus, chromosome, or gene levels in the cell will provide necessary information to AECB staff in this domain and will strengthen the scientific bases upon which regulatory decisions are made.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

3.135.2 Dosimetry of Organically Bound Tritium Derived from Diet

It is proposed to evaluate critically the existing metabolic models for the incorporation of organically bound tritium (OBT) from standard dietary intakes, and to establish whether these models can account for the observed enhanced levels of OBT in some tissues, as mentioned in the literature. If no model is found to describe these findings, adequately, then a modified tritium uptake, retention, and dosimetric model will be developed.

Tritium from CANDU nuclear generating stations and other facilities is transported readily through the environment and can be incorporated into organic molecules of the human body. The metabolism, retention, and microdistribution of these molecules into the body may differ markedly from that of tritiated water. The transfer of environmental tritium as OBT in food items and its radiological implications on man were reviewed in an AECB report, "Assessment of the Significance of Organically Bound Tritium in Environmental Materials" (INFO-0283). That report asserts that since OBT to HTO ratios of greater than unity were observed in food items at environmental tritium levels, the dose estimate based on the ICRP model for intakes of tritiated water may not be appropriate. It further recommended that reliable metabolic models should be developed for estimating the internal dose from the dietary intake of food items containing organically bound tritium.

The results of this work will therefore complement the above report and also the experimental measurements of OBT in Canadian food items taken in another AECB research project (3.135.1) and provide AECB staff with information on the appropriateness of tritium metabolic models currently used for dose estimation by its licensees. (The AECB is expecting to seek joint funding of this project with AECL and provincial utilities.)

Proponent	REPD
Technical Advisor/Evaluator	REPD (M. Legaré)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

3.135.1	$87,000

3.144.3 Paleoseismicity in the Saguenay Region

It is intended to search for additional liquefaction features produced by the Saguenay earthquake in the Saguenay-Charlevoix region. Once located, detailed investigations involving the excavation of trenches, documentation features in-situ and laboratory analyses of organic and inorganic sediments would be carried out. It is also proposed to continue documenting evidence of seismicity which may have occurred in that area prior to the recording of historical earthquakes (paleoseismicity).

This study is proposed because detailed documentation and evaluation of sand boils, begun during the summer of 1989 and continued in 1990, was completed for only 4 or 5 such features, and in a very localized area. There is a need to record data over a wider area, in order to determine whether or not a particular pattern or set of characteristics emerges and ultimately to establish, if possible, a well-founded set of criteria for recognizing evidence of paleoseismicity and the age, or ages, of such events. The application of results of this work is particularly important to areas in which seismic events have not been reported in historical time.

It is anticipated that the results of this study will provide the means for establishing criteria to recognize the effects of previous earthquakes and will also possibly aid in extending our knowledge of the seismic record in part of eastern Canada further back in time than historic seismic records allow. Should the anticipated results be realized, the AECB will be in a clear, defensible and unequivocal position to require licensees of existing, or applicants of future, nuclear facilities to conduct paleoseismic studies, particularly in areas which are not known to have experienced earthquake activity in historical times.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Tuttle, M.
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$19k	$2k	$0k	$0k	$21k

Earlier Directly-Related Contracts and Funding:

3.144.1	$13,000
3.144.2	$57,000

3.144.4 Seismically-Induced Liquefaction in the Saguenay Region

It is proposed to combine a search for additional liquefaction features in the epicentral region of the Saguenay earthquake with soil sampling and testing.

This study is proposed because liquefaction features consequent upon the 1988 Saguenay earthquake do not seem to be ubiquitous, though further mapping is required to delimit their occurrences. Besides the Ferland Valley, east of the epicenter, the only other area where these seismically-induced features have been found is along la Rivière Pikauba, the surface projection of one of the presumed earthquake rupture planes. It is important to try to find out why the liquefaction features occur in such a limited area. Is it a consequence of the location of a seismically active fault, or is it a function of the inability of certain sediments in certain positions to liquefy?

It is anticipated that the results of this study will help to establish criteria for recognizing seismically-induced fluidization and will also possibly aid in extending our knowledge of the seismic record in part of eartern Canada further back in time than historic seismic records allow. Should the anticipated results be realized, the AECB will be in a defensible position to require licensees of existing, or applicants of future, nuclear facilities to conduct paleoseismic studies, particularly in areas which are not known to have experienced earthquake activity in historical times.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Tuttle, M.
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

3.144.1	$15,300
3.144.2	$20,000
3.144.3	$20,000

3.146.1 Canadian Atmospheric Stability Indicators

It is proposed to fund a study to collect data in order to develop a method for using routine meteorological data to deduce atmospheric stability at Canadian nuclear reactor sites. Atmospheric stability is a key factor in predicting atmospheric concentrations under release conditions. The method should be applicable to other licensed facilities in Canada, such a uranium refineries.

In order to calculate the concentrations of radioactivity in the air following a release from a nuclear facility, the stability of the atmosphere must be specified. Since atmospheric turbulence is difficult to measure, this is normally done indirectly through simple indicators that are known to be correlated with direct turbulence estimates. (Temperature gradients as indirect turbulence indicators, are frequently used in accident analysis and emergency response programs.) However, these correlations between the direct and indirect indicators were developed in England and in the southern U.S. and are inappropriate for the Canadian climate, particularly in the winter when the ground is snow covered.

The results of the project are intended to provide a method to deduce atmospheric stability from simple, routine meteorological measurements for the Canadian climate, and so improve the AECB's confidence in predicted atmospheric radionuclide concentrations following releases from nuclear facilities.

Proponent	SED, REPD
Technical Advisor/Evaluator	SED (L. Truong), REPD (R. Chatterjee), PCS (B. Howden)
Project Manager	M. Mortimer
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$45k	$0k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

REGULATORY RESEARCH AND SUPPORT PROGRAM 1992/93

3.150.2 Effects of Radiation on Species Other than Man: Aquatic Organisms

It is proposed to determine whether deformities found in the chironomid population inhabiting Port Hope Harbour are the result of exposure to radiation.

Radium and uranium refining operations have contaminated Port Hope Harbour sediments with radionuclides of the U-238 and Th-232 decay chains. The sediments are also contaminated with other heavy metals. Warwick et al. (1987) found that 83% of the Chironomus spp. present in the more heavily polluted inner harbour had deformed mouth parts whereas only 14% of the Chironomus spp. in the outer harbour were deformed. They suggested that radiation induced these deformities. In the proposed study, Chironomus tentans larvae will be reared in the presence of radiation fields 1, 10 and 100 times those reported from Port Hope Harbour and in the presence of heavy metals to determine whether radiation is responsible for the deformities.

It is anticipated that data generated from this proposal will assist AECB staff in setting standards for environmental protection.

Proponent	REPD
Technical Advisor/Evaluator	REPD (L. Chamney/T. Tostowaryk)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

3.150.1	$46,000

3.151.1 Canadian Data Base for Radionuclide Transfer in the Environment

It is intended to construct a computer database for radionuclide transfer parameters in the Canadian environment.

This project is being carried out because the lack of adequate (site specific) data on parameters used to predict transfer of radionuclides in the environment often leads to global use of data from relatively few sources. However, Canada has now acquired a substantial amount of data from studies done by several industries and universities, some of them through AECB funding. These data are often preferable for Canadian applications and exist in published, but more often in unpublished, reports. There is a clear need for a central data source that represents Canadian experimental conditions and is amenable to future updates and that is easily accessible to Canadian investigators and others, including the AECB. This project will define the necessary scope of the data base, select the operating methods (software, repository of the data base, etc.), and will acquire, record and interpret suitable data.

It is anticipated that this project will provide AECB staff with convenient access to a comprehensive and centralized data source, which can be used for evaluating licensees' submissions for emission limits.

Proponent	REPD
Technical Advisor/Evaluator	REPD (K. Bundy, T. Tostowaryk)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	AECL (WL)
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$30k	$20k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

3.152.1 Production of Public Information Material on the Effects of Radiation

It is intended to produce a bilingual, non-technical video and accompanying brochure of up-to-date information on the effects of radiation on humans and on the environment.

At present, there are only a few commercially available video productions on the effects of radiation. Most of these videos are produced in the U.S.A. and are relatively old. AECB staff have been using this information material for training purposes and to inform the public about the effects of exposure to radiation. However, AECB staff feel strongly that these videos are outdated and of limited usefulness. Furthermore, little has been produced about the effects of radiation on the environment. This project is proposed because it is felt that up-to-date information in video format (with accompanying brochure), in both official languages, is urgently needed to carry out effective public information programs.

The product of this work will help AECB staff to disseminate, in an effective manner, appropriate, factual and up-to-date information to the Canadian public on the effects of radiation on humans and the environment. These materials also will enhance the visibility of the AECB.

Proponent	REPD
Technical Advisor/Evaluator	REPD (G. Poirier), OPI (H. Spence)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$80k	$0k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

3.154.1 Impact of Occupational Dose Reduction on Doses to the Public

It is proposed to study, within the framework of the ALARA principle, the impact on members of the public, resulting from a dose reduction to atomic radiation workers in a nuclear facility.

In operations such as mining, one of the main controls that is used to reduce radiation exposure is to increase the ventilation in the work areas. This, in turn, causes the radioactive emissions to increase and to be dispersed into the environment, which may subsequently result in the public receiving a greater dose of radiation. It is therefore proposed that a study be undertaken to determine what impact the reduction of dose to workers in a nuclear facility will have on the dose to members of the public.

It is anticipated that this study will help AECB staff to assess the ALARA submissions from its licensees.

Proponent	REPD
Technical Advisor/Evaluator	REPD (S.H. Ching)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$25k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

3.156.2 Geology at an Apparently Seismically Active Intersection Near Lac St-Jean

It is proposed to examine and evaluate outcrop-scale faults in the vicinity of an apparently seimically active intersection near Lac St-Jean, Quebec. The work will involve measuring fault orientations, determining the nature of faulting and identifying the faults along which repeated movements may have occurred.

This study is proposed because of the presence of intersecting major lineaments, a situation which is essentially the same as that in the immediate vicinity of the nuclear power plants at Darlington and Pickering. The only difference is that the intersection in the Lac St-Jean area appears to be the center of microseismic activity, whereas no information currently exists to make a similar pronouncement for the intersection in the area of the nuclear plants.

It is anticipated that the results of this study will provide information on brittle faulting in a seismically active, intraplate area marked by major, intersecting lineaments. If so, the results will be applicable to preparing guidelines and assessing the claims made by licensees regarding the seismogenic potential of the geological environment encompassing the nuclear power plants.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Université du Québec à Chicoutimi
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

3.156.1	$20,000

3.157.1 A Field Evaluation of Convoluted Laminations

it is proposed to select at least three exposures in which convoluted luminations occur and throughly map the structures and the entire sedimentary sequence. The environment of deposition will be determined and the origin of the convolutions will be assessed in light of the sedimentary environment. Experimental work may be a part of this study.

This study is proposed because convoluted laminations are indicators of a sudden shock being applied to water-laden sediments. They are fairly common in the unconsolidated glaciofluvial sediments of eastern Canada, but their origin is in question. There are classical interpretations related to rapid sedimentation, ice loading, or boulders dropping into sediments from freely floating, but progressively melting, ice blocks. However, there is the distinct possibility that they are caused by earthquakes, whether tectonically induced or triggered by sudden shocks attendant upon glacial rebound. Knowledge of the origin of these features could have implications for seismic risk assessments.

It is anticipated that the results of this study will provide evidence that convolutions do, or do not, form in the same sedimentary environment. If the former, then field evidence would suggest that a sedimentary origin is very likely, although seismicity cannot be ruled out. If, however, these structures form under a variety of sedimentary conditions, and if these include quiet water conditions, a seismic origin would seem rather likely.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	University of New Brunswick
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

3.160.1 Radionuclide Analysis in Dissolution Tests

It is intended to measure the quantity of uranium in samples obtained from in vitro assays in which the solubility of uranium ore dust particles is tested in the presence of lung macrophages.

The University Hospital of Sherbrooke (Quebec) (CHUS) is carrying out a research project for the AECB, aimed at determining the influence of lung macrophages on the solubilization of radionuclides contained in uranium ore particles. This research is the first known attempt to use macrophages in dissolution tests of uranium ores. No information exists in the literature on the subject. The requested analyses are necessary to guide the CHUS in determining the optimum quantities of macrophages and uranium ore dust compatible with realistic biological conditions and good analytical sensitivity.

It is anticipated that the results of this project will provide analytical data for adjusting parameters and optimizing dissolution procedures.

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	Becquerel Laboratories Inc.
Principal Investigator	Dr. R. Robertson
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$15k	$3k	$0k	$0k	$18k

Earlier Directly-Related Contracts and Funding:

3.123.1	$184,000

3.161.1 Radiation Facts Booklet

It is intended that an illustrated, easy-to-read and uniquely Canadian radiation facts booklet be prepared by combining, up-dating and Canadianizing the best of existing publications of this nature, such as the U.K. NRPB's "Living with Radiation". (The booklet would be complemented by, and coordinated graphically with, the print product of project 3.152.1.)

No definitive Canadian reference of this nature exists, and none is in preparation. While there are a number of nuclear industry brochures that address the topic on a limited basis, for conflict of interest/public perception reasons, these are not suitable for distribution by the AECB. One produced by the Canadian Institute for Radiation Safety (CAIRS) with AECB collaboration has a special emphasis on uranium mine and mill workers, and is also too narrow in scope. International versions of such a document have proven less than satisfactory for AECB purposes: they are extremely expensive, there is no Canadian content, and the most recent one from the IAEA contained two serious errors of fact.

This project will provide an information vehicle visibly identified with the AECB, for use in public communications programs, including media relations, worker training (licensees), youth education activities (it might be adopted as an official reference for science classes), and for orientation training of new AECB staff.

Proponent	OPI
Technical Advisor/Evaluator	OPI (H. Spence), REPD (G. Poirier)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$15k	$15k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

3.162.1 Monitoring Uranium Emissions from a UF6 Plant Stack

It is the purpose of this project to evaluate the static isokinetic sampling device and technique currently used in measuring the particulate emissions through the process exhaust stack on CAMECO's West uranium hexafluoride production plant in Port Hope, Ontario, and on the basis of this evaluation, to assess the validity of the data on the uranium discharged to the atmosphere from that source.

The quality of these data is in doubt for two reasons. First, because the design of the stack causes turbulence in the process exhaust flow, it is believed that this leads to non-uniform distribution of particulate material across the stack. These effects raise questions about the consistency and representativeness of the samples taken from the stream. Secondly, in a test run to compare the two methods, there was a marked difference between data from the static isokinetic sampling device and data derived using the Ontario Ministry of the Environment Method 5 Source Testing Code.

It is anticipated that the findings from this project will enable AECB staff to assess the accuracy and soundness of the data on the uranium emissions from this source. This information is required for determining compliance with limits prescribed in the facility operating licence.

Proponent	UFD
Technical Advisor/Evaluator	UFD (A. Ghosh)
Project Manager	E. Rabin
Review Panel	
Contractor	Autolycus Research
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$41k	$0k	$0k	$61k

Earlier Directly-Related Contracts and Funding:

3.163.2 The Origin of Conical Hills, Charlevoix Seismic Zone - Phase II

It is proposed to cut trenches in, and evaluate exposures of, a second conical hill on the Gouffre River terrace north of Baie St. Paul, Québec.

This work is proposed because some of these post-glacial features occur in the heart of the Charlevoix Seismic Zone and appear to have formed as a result of the upward movement of liquefied sand and gravel which domed the overlying sediments. The hill excavated in 1991 (project 3.163.1) was formed in clay and has been interpreted as originating from a landslide. The hill to be excavated for this project would be in sand to document and interpret the internal structures.

It is anticipated that the results may suggest a seismic origin for the hills which, if borne out, will provide geological evidence of earthquake activity. The results could then be used in areas in which no major seismic activity has been recorded to date, but in which there may, nonetheless, have been major seismic activity prior to recording of such events. As in the case of the other seismotectonic projects, the information could be used by the AECB to require licensees, in assessing seismic hazard, to look for, and evaluate, isolated conical hills in regions of proposed or existing nuclear facilities.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	L'Université Laval
Principal Investigator	Jean-Yves Chagnon
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

3.163.1	$5,000

3.164.1 Carbon-14 in Lakes: Appropriate Risk Assessment

It is proposed to assess the degree of C-14 contamination in the water, sediments, and biota of two Canadian Shield lakes that historically received deliberate C-14 additions. These data will be used to assess the radiological risk to human health from C-14 in aquatic systems.

Current assessment relies on specific activity models or transfer coefficients from water to biota to assess the radiological risk to humans from C-14 in aquatic ecosystems. Some of the added C-14 may be biologically incorporated by algae and enter the detritus food chain. Here C-14 may persist and be transferred into the human food chain via fish. At the Experimental Lakes Area in northwestern Ontario, an opportunity exists to study this risk in two lakes which received C-14 additions in the 1970's. By assessing the degree of contamination of specific biological compartments in these lakes, the long-term risk associated with C-14 release to water bodies can be evaluated. In addition, insight into carbon pathways in Canadian lakes will guide the development of a more appropriate model to assess the long-term risk associated with C-14 release. The development of such a model will form the basis of subsequent phases of the work.

It is anticipated that this project will provide AECB staff with data to evaluate the long-term consequences of C-14 release to aquatic systems. These data will indicate whether current models correctly assess the risk to humans and the environment of accidental C-14 release, and whether it is necessary to develop an improved model of C-14 behaviour in lakes.

Proponent	REPD
Technical Advisor/Evaluator	REPD (L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$35k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

3.165.1 HTO and C-14 Cycling following Chernobyl

It is proposed to evaluate the uptake and cycling of HTO and C-14 following the Chernobyl accident by measuring the distribution of these two nuclides in the cellulose from the annual rings of trees collected from the Chernobyl area.

In severe accidents, HTO and C-14 may be released from CANDU reactors. Releases of HTO and C-14 did occur during the Chernobyl incident. However there has been little study of these two isotopes in the environment surrounding Chernobyl. Analyses are needed to compare the cycling of HTO and C-14 following a severe accident with results derived from continuous operations. Data bases from continuous operations are available already from work done for the Canadian Fusion Fuels Technology Project (CFFTP), CANDU Owners Group (COG) and AECL Research by R.M. Brown.

It is anticipated that this work will complement international efforts led by the IAEA to evaluate the cycling of other nuclides (e.g. Cs-137) following Chernobyl.

Proponent	REPD
Technical Advisor/Evaluator	REPD (T. Tostowaryk, R. Utting)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

3.168.1 Environmental Health Scoping Study at BHWP

It is intended to carry out a multidisciplinary scoping study to investigate the environmental health concerns associated with the Bruce Heavy Water Plant (BHWP).

This study is being undertaken because an earlier investigation by Agriculture Canada of the animal husbandry practices on the farm in question did not uncover any sign of toxic substances in the farm animals which died from still-unknown causes. Since no obvious cause of death has been determined, it would be advisable for the AECB to perform a scoping study.

It is anticipated that this study will provide the AECB with an overall view of the problem and clear direction for further investigation.

Proponent	PRDB, SEDA
Technical Advisor/Evaluator	PRDB (C.A. McDermott), SEDA (L. Truong), REPD (T. Tostowaryk)
Project Manager	M. Lupien
Review Panel	
Contractor	Alberta Environmental Centre
Principal Investigator	Dr. M. Prior
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$4k	$30k	$0k	$0k	$34k

Earlier Directly-Related Contracts and Funding:

3.169.1 Computer Software Quality Assurance

It is proposed to obtain consulting services concerning quality assurance for analytical software used in nuclear engineering. The consultants would review the types of analytical software used in nuclear engineering, including those to be covered by the proposed Canadian Standards Association (CSA) quality assurance standard in the N286 series and recommend to AECB staff appropriate quality assurance approaches and procedures for the design, development and maintenance of such software.

AECB staff is required to assess licence submissions concerning the predicted performance of nuclear reactors and nuclear waste disposal facilities. Most of these performance predictions are generated by software modelling packages currently under development by industry and government agencies. Confidence that all of the requirements associated with model design, development and testing have been identified and implemented, is dependent on the effectiveness of the software quality assurance programme. AECB staff are participating in a CSA committee to establish a quality assurance standard in the N286 nuclear series applicable to analytical software such as codes to simulate thermohydraulic processes or software tools to perform Computer Aided Design.

This activity will assist AECB staff in assessing the effectiveness of the licensees' quality assurance programme, and in contributing more effectively to the N286 analytical software committee.

Proponent	CQAD, WID, SEDA, SEDE
Technical Advisor/Evaluator	CQAD (D. Scrimger), WID (P. Flavelle), SEDA (J. Khosla), SEDE (R. Taylor)
Project Manager	Y. Akl
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

3.170.1 MAGNEC Five-Year Progress Report

It is intended to compile the information and to prepare the 5-year report on all geoscientific work undertaken under the auspices of MAGNEC. This project will receive partial funding from the Geological Survey of Canada.

Several projects in the MAGNEC program have been funded by the AECB during the past 5 years. This project is proposed in order to put together a coherent summary of all MAGNEC-related work conducted to date, along with conclusions and inferences from that work, and recommendations for future studies.

It is anticipated that the results of this report will demonstrate the achievements that have been made in attempting to improve seismic hazard assessments.

Proponent	RSDA
Technical Advisor/Evaluator	RSDA (J. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Grier, M.
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$22k	$15k	$0k	$0k	$37k

Earlier Directly-Related Contracts and Funding:

11.106.1	$5,000

3.171.1 Bioavailability of Iodine in a Simplified Aquatic Food Chain

The bioavailability of a radionuclide is often determined by its speciation. However, there is little information on the influence of speciation on uptake of radionuclides in freshwater ecosystems. This proposal is to investigate the effect of speciation on assimilation of iodine (I-131) by fresh water algae and subsequent transfer of iodine in a simplified aquatic food chain.

Iodine is a biogenic element that is preferentially assimilated as iodide by marine algae. In fresh water, iodine concentrations are low, about one sixtieth of those reported for the ocean. Because of the low concentrations of iodine in fresh water, it has been suggested that iodine is not essential for algal growth. This proposal investigates whether iodine enhances algal growth and the effect of speciation (iodide and iodate) on food chain (zooplankton and fish). The effect of algae on the conversion of iodine to organic iodine, eg., methyl iodine, will also be investigated. In addition , the importance of respiratory (gills) versus ingestion pathways for the uptake of iodine by fish will be investigated.

This proposal will provide a better understanding of the mechanisms of iodine behaviour and pathways of transfer in the aquatic environment. Information gained from the project will allow AECB staff to predict more accurately the fate of radioactive iodine in aquatic ecosystems in the event of an accidential release.

Proponent	REPD
Technical Advisor/Evaluator	REPD (T. Tostowaryk)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$35k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

3.172.1 Use of Evergreen Needles to Assess Airborne Radioactivity

It is proposed to evaluate the potential use of evergreen needles to assess airborne radioactivity in the vicinity of nuclear facilities.

Evergreen needles are potentially useful for assessing airborne contaminants. For example, pine needles have been used to monitor I-129 in the environment near fuel reprocessing plants. The concentrations of contaminants in the needles would be proportional to the time-integrated exposure. While pine trees only retain their needles for 2 years, spruces and balsams retain theirs for up to 7 or 8 years. Thus, they retain a historical record of previous exposures, as well as current exposures and it is easy to identify the ages of the needles from the structure of the trees. It is expected that the record for C-14 and H-3 (as OBT) should be permanent since these radionuclides will be incorporated into the structure of the needles. Therefore it is proposed to study C-14 and H-3 (as OBT) in spruce and balsam needles from areas around Canadian nuclear facilities which have emitted these radionuclides.

These results will be useful for AECB staff to assess previous experiences resulting from airborne releases from long-lived radionuclides from Canadian nuclear facilities.

Proponent	REPD
Technical Advisor/Evaluator	REPD (L. Chamney/T. Tostowaryk)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$20k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

3.173.1 Review of Soil to Plant Transfer Models

It is proposed to conduct a critical review of the literature to evaluate the need and feasibility of improving the currently used plant uptake empirical ratio models in radiological assessments.

At present, the transfer of radionuclides from soils to plants is modelled by relatively simple empirical ratios. However, there is considerable uncertainty in the results from such transfer models and, therefore, there are limitations to this approach in the assessment of health impacts from soil-borne radionuclides. In recent years, there have been proposals in the literature for the use of more refined models to estimate transfer of radionuclides from soils to plants. Detailed studies on soil to plant transfer processes for various radionuclides have also been published in the literature. Therefore, a detailed review and critical evaluation of the literature will provide the information on whether it is practical to improve upon the current empirical ratio models, and thus provide more reliable predictions of plant uptake of soil-borne radionuclides.

The results of this study will help AECB staff in deciding whether a more detailed model than the empirical-ratio model is needed for the estimation of soil to plant uptake in radiological assessments.

Proponent	REPD
Technical Advisor/Evaluator	REPD (L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$25k	$25k	$75k

Earlier Directly-Related Contracts and Funding:

3.174.1 Uncertainty in Environmental Pathways Analysis Models

It is proposed to fund a review of the principal sources of uncertainty in environmental assessment models used in evaluating the impacts of nuclear facilities in Canada. The review will also evaluate the magnitude and significance of these uncertainties, and will provide an overview of appropriate methods for uncertainty analysis.

Environmental assessment models are used by AECB licensees to estimate impacts to the public from nuclear facilities and to derive emission limits for such facilities. In addition to reviewing and assessing the models used and the impact estimations prepared by licensees, AECB staff use regulatory models to conduct independent evaluations of licensing submissions and issues. Because these models only represent an approximation of reality, the results and interpretation of model-based assessments are inherently uncertain. Regulatory interpretation of the results of environmental assessment models therefore requires an understanding of the source, magnitude and significance of their predictive uncertainties.

The results of this study will be used by AECB staff to help to ensure the credibility of regulatory decisions based on environmental impact assessment modelling, and to assist in identifying priority issues in the analysis of modelling uncertainties.

Proponent	REPD
Technical Advisor/Evaluator	REPD (L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$25k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

3.175.1 Further Development of the CHER-URB Urban Contamination Model

It is proposed to fund further development and to test a computer model developed in the AECB research project entitled: "Significance of Urban Pathway in Assessing Public Dose: (3.145.1), in order to refine the assessment of the radiological impacts of nuclear facilities on the public. The CHER-URB urban contamination and dose model is a tool for assessing potential doses to humans (inhalation, external, immersion) as a result of atmospheric contamination of urban environments from nuclear facilities.

Several nuclear facilities in Canada are located in the vicinity of large urban environments, and thus routine or accidental releases of radioactivity could affect urban populations. The urban environment has unique features that generally are not taken into account when assessing natural or semi-natural environments. Such features relate mainly to deposition (dry or wet) and retention of radionuclides on urban surfaces, to transfer processes within the urban environment and to the calculation of external and internal radiation doses. This was especially recognized in European urban areas following contamination from the Chernobyl accident in 1986. Assessment of the potential impacts of nuclear facilities by AECB staff must give consideration to urban contamination concerns, and requires reliable tools. Further development work will increase the reliability of CHER-URB and the AECB's capability to assess radiological impact through: (i) provision of a more accurate dosimetric model for assessing external doses; (ii) provision of model routines for evaluating uncertainties in results; and (iii) provision of model routines for evaluating the effects of weathering, runoff and decontamination processes on doses. Model improvements will be made in light of relevant post-Chernobyl research, such as those being discussed within the VAMP program of the IAEA. The updated code will be run on a test case to evaluate its reliability, and to identify limitations and sources of uncertainty.

The results of this project, an updated and documented version of CHER-URB, will provide AECB staff with a useful decision-aiding tool for assessment of radiological impacts to the public following atmospheric contamination of urban environments from nuclear facilities.

Proponent	REPD
Technical Advisor/Evaluator	REPD (L. Chamney)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$45k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

4.101.2 Modification of Equipment for Uranium Ore Dust Study

It is intended to modify and upgrade the dust generators, dust monitors and inhalation chambers to be used in the full-scale inhalation experiment (project 4.101.3) of the project entitled "Health Effects of Inhaled Uranium Ore Dust", according to the findings of the preliminary inhalation study (project 4.101.1).

The last of the tasks to be performed before the full-scale, two-year inhalation study, which will involve about 270 animals, was a 15-week preliminary inhalation test with 72 animals. This preliminary test achieved its purpose in demonstrating that the animals could withstand long duration exposures to the intended concentrations of dust. The other objective of the preliminary test was to evaluate the performance of the dust generators, dust monitors and inhalation chambers, when used for long periods of time with actual high-grade uranium ore dust. This was the first time that equipment of this type was used with pulverized high-grade Canadian uranium. The test revealed that bins on the dust generators required modification in order to produce a continuous flux of ore powder, that simple dust monitors, based on direct light-beam scattering, had to be installed to monitor continuously the consistency of dust concentration sent to the inhalation chambers, and that seals on the inhalation chambers had to be improved.

It is anticipated that the work to be carried out will enable the two-year long full-scale inhalation study to be conducted with a laboratory apparatus that has been corrected for all the weaknesses observed during the preliminary tests.

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	AECL Research - CRL
Principal Investigator	Dr. R. Mitchell
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$93k	$2k	$0k	$0k	$95k

Earlier Directly-Related Contracts and Funding:

4.101.1	$1,030,000

4.101.3 Study of the Health Effects of Inhaled Uranium Ore Dust - Phase 3

It is intended to continue funding the third phase of the ongoing project to study the health effects (induction of cancer of the lung, cellular defects) on experimental animals exposed to different concentrations of airborne high grade uranium ore dust. Inter-organ transfer of radionuclides, such as uranium, radium and thorium, and the rate of clearance of these radionuclides from the lung will also be studied.

This study was undertaken because Canadian uranium miners are exposed to airborne mineral dust that contains uranium, thorium, and all their decay products, some of which are highly radiotoxic. In high grade ore mines, uranium content in the dust may reach several tens of percent and may represent the predominant occupational radiation hazard. Since uranium miners have always been exposed to a mixture of external gamma radiation and internal radiation from radon decay products and ore dust, it has not been possible to separate the contribution of each component to the observed rate of lung cancer. This was of little consequence as long as radon daughters were the predominant hazard, but this becomes an issue in today's Saskatchewan mines. Since the initiation of the project, the dust generators, dust concentration monitors and the nose-only inhalation apparatus were built and tested; the adequacy of the rat strain has been verified; the maximum dust concentration tolerable without acute toxicity effects has been determined. With the advice of the Review Panel, the experimental procedure for the final, full-scale experiment has been prepared.

In addition to the partial information already obtained, it is anticipated that this study will indicate whether inhaled high grade uranium ore dust induces lung cancer in rats whose response to radon daughters is already known. An attempt will be made to quantify the dose-response relationship. Short- and long-term metabolism of the most significant naturally-occurring radionuclides will also be studied and the data will be used to refine current internal dosimetric models.

Proponent	UFD, REPD, HES
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	M.R. Avadhanula
Review Panel	03
Contractor	AECL Research
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$45k	$285k	$300k	$70k	$700k

Earlier Directly-Related Contracts and Funding:

4.101.1	$1,030,000
4.101.2	$95,000

4.103.2 Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities

It is intended to continue funding this project to determine experimentally the size distribution, the activity distribution and the solubility of airborne uranium-bearing aerosols in all Canadian uranium mines and mills, refineries, conversion facilities and fuel fabrication plants.

This work was undertaken to quantify the hazard presented by airborne radioactive long-lived materials in the concerned facilities. The parameters (size distribution, activity distribution, radionuclide composition and dissolution rate in simulated lung fluid) which are necessary to calculate the committed effective dose equivalent from exposure data must be determined in order to evaluate quantitatively, this specific radiation hazard.

It is anticipated that this study will indicate the magnitude of the risk from long-lived particulates in uranium producing and manufacturing industries. It will also provide supporting information for any forthcoming regulation on long-lived dust and will facilitate interpretation of bioassay data for the purpose of the radiation protection of the workers at these facilities.

Proponent	UFD, REPD
Technical Advisor/Evaluator	UFD (G. MacDonald), REPD (F. Horvath, S. Ching)
Project Manager	K.P. Ho
Review Panel	05
Contractor	MacLaren Plansearch Inc.
Principal Investigator	A. Van der Vooren / Dr. J. Hicks
Category	0

Past	91/92	92/93	93/94	Future	Total
$245k	$30k	$60k	$9k	$0k	$344k

Earlier Directly-Related Contracts and Funding:

84.3.22	$49,000

4.106.4 Ontario Miners Mortality Study - Annual Update

It is intended to update the mortality, exposure and smoking data of Ontario uranium miners for the three-year period 1987 to 1989 and annually thereafter until FY 1992/93, at which point a detailed mortality analysis will be conducted to obtain improved risk estimates.

The previous phases of the Ontario Miners Mortality Study have revealed that the update on an annual basis of mortality and histology data, as well as of exposure and smoking histories, is useful for detecting any annual trend in the mortality pattern, and any influence of yearly variation of smoking habits on the incidence of lung and other cancers among the aging population of Ontario uranium miners. Furthermore, the annual update may be pooled together about every five years and the updating of risk estimates may be achieved with minimum delay and cost.

It is anticipated that the results of this study will considerably improve the efficiency of the five-year mortality analysis for lung cancer risk estimates. Furthermore, the annual update will enable the AECB to detect annual trends in the mortality pattern, and the influence of confounding factors on the induction of lung and other cancers among the uranium miners. (This project is a joint study with Ontario Ministry of Labour (OML) and Workers' Compensation Board of Ontario (WCB) on a one-third cost-sharing basis.)

Proponent	UFD, REPD, HES, OML, WCB
Technical Advisor/Evaluator	UFD (A. Balint), REPD (C. Pomroy, S. Ching)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	Statistics Canada
Principal Investigator	Mr. Al Wheeler
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$10k	$15k	$10k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

4.106.1	$60,000
4.106.2	$180,000
4.106.3	$53,000

4.108.2 Methodology for Determining the AMAD of Long-Lived Dust

It is proposed to develop a practical method for determining accurately, by means of a cascade impactor, the activity median aerodynamic diameter (AMAD) of long-lived radioactive dust, in uranium mine/mill facilities. A cascade impactor separates the dust into different size fractions, and alpha activity measurements are made of each of the different size fractions. The AMAD is essentially a term describing the median dust size with respect to the radioactivity of the dust. The determination of AMAD is required because it is used in the calculation of the annual limit on intake (ALI) for long-lived radioactive dust.

This project is being proposed because, in the previous research project, 4.108.1, entitled "Intercomparison of Dust Sampling Instruments", the performance of two cascade impactors was compared. One instrument was a full-size, stationary model and the other a portable model. The full-size model is generally accepted as a reference instrument. It was found from the field trials that the results from the portable instrument differ significantly from those obtained by the full-size model. Since it is not practical to use the full-size model in underground mines for compliance monitoring purposes, it is necessary to modify or calibrate the portable instrument with a view to making its performance comparable to that of the full-size model.

It is anticipated that the results of this project will provide a practical tool or methodology for determining the AMAD, by means of a portable cascade impactor, thereby assisting the AECB in determining more accurately the doses due to exposures to long-lived radioactive dust.

Proponent	REPD
Technical Advisor/Evaluator	REPD (K. Bundy, S. Chingh) UFD (R. McCabe)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$20k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

4.108.1	$90,000

4.108.3 Time Variability of AMAD of Long-Lived Radioactive Dust

It is proposed to determine the time variability of the activity median aerodynamic diameter (AMAD) of long-lived radioactive dust, in uranium mine/mill facilities. The AMAD is one of the parameters from which the annual limit on intake (ALI) for airborne radioactive dust is calculated. The AMAD is essentially a term describing the median dust size with respect to the radioactivity of the dust.

Until recently, it was assumed that the AMAD would be fairly constant in the workplace, as long as there was no major change in the work practices. However, a recent research study (4.108.1, Phase 2, Part 3) indicated a 67% increase in the AMAD in workplaces over a two-week period. This finding raises some concern regarding the variability of the AMAD over time. Because the AMAD is used in the determination of the annual limit on intake, a change in the AMAD should lead a change in the ALI. It is, therefore, necessary to determine whether the AMAD varies significantly over time in workplaces of uranium mines and mills.

It is expected that the information gathered in this research project will provide AECB with an indication of the frequency with which the AMAD should be determined, and will allow a more precise determination of the ALI for airborne long-lived radioactive dust.

Proponent	REPD
Technical Advisor/Evaluator	REPD (K. Bundy), UFD (R. McCabe)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$55k	$45k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

4.108.1	$90,000
4.108.2	$60,000

4.112.1 Electrical Charge of Radioactive Aerosols in Uranium Mines

It is proposed to measure the fraction of positively and negatively charged aerosol particles carrying radon and thoron daughters, to determine the number of elementary charges carried by individual charged particles, and to relate these parameters to the ionization conditions and carrier aerosol parameters that prevail in underground uranium mine atmospheres.

The radiation dose delivered to the lung from inhaled radon and thoron daughters depends upon the deposition of these radioactive particles in the respiratory tract, which in turn depends on the size distribution and electrical charge of these particles. The aerosol size distribution itself is governed in part by the electrostatic attraction between ultrafine radon and thoron daughters and carrier aerosol particles generated by mining activities and diesel engines. Owing to the ionization induced by relatively large concentrations of alpha radiation emitters, the consequent phenomena (collectively referred to as "atmospheric electricity") play an important role in shaping the resulting radioactive aerosol actually inhaled by miners. To date, no study has been carried out in Canadian mines to determine the electrical properties of airborne radon and thoron daughters.

It is anticipated that the findings of this study will, for the first time, bring information to AECB staff on the electrical state of radioactive aerosols in mines. This information may also be used in interpreting monitoring and dosimetry data and may serve to complement the computer modelling of mine atmospheres.

Proponent	HES, EMR (J. Bigu)
Technical Advisor/Evaluator	REPD (S. Ching)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$20k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

4.118.2 Mortality Analysis of Beaverlodge Uranium Miners from 1981-1989

It is intended to update the mortality analysis of the uranium miners in Beaverlodge, Saskatchewan, from 1981 to 1989, using computerized linkage to the Canadian Mortality Data Base at Statistics Canada. Additionally, the cancer incidence data for this cohort from 1975 to 1989 will also be analyzed to improve the statistical significance of the mortality information which will be used to obtain revised risk estimates for lung cancer per unit exposure to radon daughters.

The risk estimate for lung cancer obtained from the previous mortality analysis of the Beaverlodge uranium miners for the period from 1950 to 1980 was about three times the values reported for the Newfoundland fluorspar miners, about three to six times the values reported for the Ontario uranium miners, and six to nine times the risk estimates obtained from the study of uranium miners in the Colorado Plateau. There is some concern, both nationally and internationally, about the accuracy of the risk estimate obtained from the study of Beaverlodge uranium miners. As a consequence, both the mortality data and radon daughter exposure estimates will be re-examined in order to reduce the uncertainties in the risk estimates. (The re-evaluation of radon daughter exposures for this group of uranium miners is being carried out in the previous study, 4.118.1.)

It is anticipated that the results of this study will improve the risk estimates for lung cancer due to exposure to radon daughters.

Proponent	REPD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	REPD (C. Pomroy, S. Ching)
Project Manager	V. Elaguppillai
Review Panel	02
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$15k	$20k	$25k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

4.118.1	$77,000
7.095.1	$59,000

4.126.1 Computerized Mortality Search Procedures

It is proposed to fund the preparation of a technical report which will document the structure of the files, methodology, flow of information, and data quality control checks used in the 1989 mortality search update of the Ontario Miners Mortality Study.

This project is proposed because, in the past decade, computer linkage methodologies have been improved greatly and new procedures have been developed. Weights have been derived for the parameters to be matched, and more links have been generated by using intermediate files to facilitate the lingage. For instance, tax files and drivers licence follow-up allow for the possibility of an alive follow-up. The ability to identify individuals unambigously has been facilitated by the use of the Social Insurance Number Index. These procedures allow for the follow-up of worker cohorts who have moved to other locations in Canada and also to other jobs. Because updates to the mortality data bases are being done on a regular basis, it would be a logical step to document the methods being used to facilitate future updates. The data from these studies are being used extensively, internationnally, to improve the risk estimates for radiation-induced lung cancers.

The results of the technical report prepared could prove valuable for persons involved in any pooling of data on radiation workers. Recommendations for future improvements to epidemiological studies will be made. This documentation is particularly important for the follow-up of Ontario miners, as many mines are being reduced in staff (e.g., Elliot Lake) and the workers are migrating to work in other jobs in other centres.

Proponent	REPD, HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	REPD (C. Pomroy, S. Ching)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

4.130.1 Evaluation of Radon Daughter Exposures of Port Radium Miners

It is intended to re-evaluate the radon daughter exposures (in working level months (WLM)) received by nearly 2100 miners who worked at the uranium mines in Port Radium in the Northwest Territories for the period from 1930 to 1960, and who may have had previous exposures to radon daughters in other mines.

The risk estimate for lung cancer obtained from the previous study of Port Radium uranium miners, by Howe et al., was 0.27% per WLM. This value is at the lower end of the range of relative risk estimates (0.3 to 3.3 % per WLM) reported for other Canadian and international studies (Ontario uranium miners 1.3%, Newfoundland fluorspar miners 0.9%, Beaverlodge uranium miners 3.3%, U.S. Colorado uranium miners 0.8%, Czechoslovakian uranium miners 1.8%, and Swedish iron miners 1.4%). Among the Canadian studies, exposures received by both the Ontario uranium miners and Newfoundland fluorspar miners were re-evaluated using improved techniques and additional information on exposure histories, which resulted in better agreement between their respective revised risk estimates (as stated above). The exposures received by the Beaverlodge uranium miners are being re-evaluated (project 4.118.1) and the results will be used in an updated mortality analysis (4.118.2). Therefore, it is important to re-evaluate the exposures of individual miners who worked in the uranium mines in Port Radium, taking into account exposures received by them in other mines, as well as their work histories, and design characteristics of the mines.

It is anticipated that the results of this study will give the AECB improved exposure estimates for Port Radium uranium miners. These estimates will be used in an updated mortality analysis of Port Radium uranium miners (Project 4.130.2) to derive improved risk estimates for lung cancer due to exposure to radon daughters.

Proponent	UFD, REPD, HES
Technical Advisor/Evaluator	UFD (D. Corkill), REPD (C. Pomroy, S. Ching)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$5k	$15k	$55k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

4.130.2 Mortality Analysis of Port Radium Uranium Miners (1950-1989)

It is proposed to update the mortality analysis of the uranium miners in Port Radium, in the Northwest Territories, for the period from 1950 to 1989, using computerized linkage to the Canadian Mortality Data Base at Statistics Canada. Additionally, the revised exposure estimates obtained from the previous project (4.130.1) will be used with the mortality data to obtain revised risk estimates for lung cancer per unit exposure to radon daughters.

The risk estimate for lung cancer obtained from the previous mortality analysis of the Port Radium uranium miners is known to have a number of uncertainties, including the uncertainty in its exposure estimates. Furthermore, since the previous analysis, several additional years of mortality data have been accumulated by the Canadian Mortality Data Base. It is therefore necessary to re-evaluate the risk of lung cancer per unit exposure to radon daughters, using both the revised exposure information (4.130.1) and the additional mortality data to the end of 1989.

It is anticipated that the results of this study will improve the risk estimates for lung cancer due to exposure to radon daughters. (This is expected to be a joint study with the National Cancer Institute of Canada (NCIC) on an equal cost-sharing basis.)

Proponent	UFD, REPD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	UFD (D. Corkill), REPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$25k	$0k	$65k

Earlier Directly-Related Contracts and Funding:

4.130.1	$55,000

4.132.1 Smoking Histories of Fluorspar Miners

It is proposed to update the smoking histories of former fluorspar miners in St. Lawrence, Newfoundland from 1978 to 1990. This information will be used to determine the extent of interaction between smoking and exposure to radon daughters on the incidence of lung cancer among the former fluorspar miners, and to calculate the risk of lung cancer per unit exposure to radon daughters, taking the effect of smoking into account.

The previous smoking history survey of the fluorspar miners in St. Lawrence, Newfoundland was completed in 1978. A total of 755 miners were contacted in this survey, funded by the Atomic Energy Control Board. To date, nearly 720 miners of this cohort are known to be alive in the St. Lawrence region. Furthermore, nearly 40% of these miners are estimated to have quit smoking during the past 13 years since the last survey. If this estimation is accurate, it might influence the risk estimate for lung cancer due to radon daughters, because of the known interaction between smoking and radon daughters. It is therefore important to conduct a survey to determine the actual number of current smokers among the former miners.

It is anticipated that the results of this survey will provide information on the interaction between smoking and exposure to radon daughters, and will improve the accuracy of risk estimates for lung cancer owing to exposure to radon daughters, in the absence of radioactive dust in the working environment.

Proponent	REPD, HES, LCDC (NHW)
Technical Advisor/Evaluator	REPD
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

4.133.1 Lung Cancer Among Uranium Miners in Germany

It is proposed to conduct an epidemiological study of lung cancer among uranium miners in Germany, jointly with federal German authorities, and to evaluate the risk of lung cancer per unit exposure to radon daughters, taking confounding factors present in the work place into account.

Nearly 500,000 uranium miners are known to have had significant exposure to radon daughters during their employment in underground uranium mines in the former East Germany. A detailed epidemiological study of these miners, the single largest group of uranium miners in the world, would be expected to improve the accuracy of the risk estimates for lung cancer due to exposure to radon daughters. The scientists at the Institute for Radiation Hygiene of the Federal Health Office, in Germany, are currently developing appropriate methodologies to carryout a full-scale epidemiological study of this large cohort of uranium miners. They are seeking Canadian participation in the areas of record linkage and radon daughter exposure re-evaluation, areas in which Canadian expertise has been well recognized worldwide. Canadian participation in this very important study would influence the quality of the results and their impact on setting limits for exposure to radon daughters in uranium mines.

It is anticipated that the results of this study will improve the accuracy of the risk estimates for lung cancer owing to exposure to radon daughters, and will improve our understanding of the influence of various confounding factors on these risk estimates. (This is expected to be a joint study with the Institute for Radiation Hygiene (GSF) of the Federal Health Office, Neuherberg, Germany, and the Atomic Energy Control Board. The major contribution of $1.5 million will come from the GSF. The AECB will contribute technical expertise, costing $20K per year, totalling $80K during the anticipated four-year period of this study.)

Proponent	REPD, HES, GSF
Technical Advisor/Evaluator	REPD
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$20k	$40k	$80k

Earlier Directly-Related Contracts and Funding:

4.134.1 Tools for Measuring the Unattached Fraction for Uranium Mines

It is proposed to review the state of the art in instruments and methods for measuring the unattached fraction of radon decay products in uranium mine and mill atmospheres.

In terms of deposition in the human respiratory tract, the unattached fraction of radon decay products, consisting of small particles of high mobility, contributes ten to twenty times the radiation dose (per unit intake) than does the fraction attached to larger "carrier" aerosols. Further, the fraction of unattached radon decay products is larger in open pits and mills than in underground mines. In the latter facilities, it becomes more necessary to evaluate the dose delivered to the lung by the unattached fraction. Some tools and methods are currently available for measuring the unattached fraction, but it is not certain whether they are suitable for field applications. It is important for the AECB to be kept abreast of developments in this area in order to assess properly the use of these tools and methods and to determine the extent to which they can be used in Canadian facilities. Also, if the conclusion of this study demonstrates a need to correct or adapt existing procedures, specific guidance could be issued by the AECB.

This project will provide AECB staff with information on what instruments and methods are currently available for measuring the unattached fraction, their characteristics, and relative merits. Also, it is anticipated that the proposed research will provide information to refine the determination of doses received by uranium miners in Canada.

Proponent	UFD, REPD
Technical Advisor/Evaluator	UFD (R. McCabe), REPD (S. Ching, K. Bundy)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

4.135.1 A Method for Measuring Uranium in Dust Samples

It is proposed to conduct a feasibility study to determine the sensitivity of a method that associates neutron irradiation with detection of fission fragments in a plastic detector, in order to improve the monitoring of radiation doses from radioactive dust in uranium mines and mills. This method would be used to measure the quantity of uranium present in atmospheric dust samples collected in mines and mill atmospheres. The unit cost of this type of analysis on samples collected routinely in Saskatchewan mines and mills will be evaluated.

In uranium mines and mills, uranium-bearing dust could be the single most important source of radiation exposure, exceeding that of radon decay products and gamma radiation combined. In some Saskatchewan facilities, exposures to radon decay products are measured by means of continuous personal samplers, the filters of which also collect uranium-laden dust. With the implementation of the new regulatory limits, it would be desirable to be able to measure on these filters, with an acceptable accuracy, quantities in the neighbourhood of 0.3 micrograms of uranium. Traditional gross alpha counting is neither a method sensitive nor reproducible enough, because the background count rate is about 3 times that of the uranium source. In addition, the result is unpredictable because the background count rate is significantly affected by the large variations of radon concentration found in the atmosphere. Furthermore, the self-absorption of alpha particles in dust samples is unknown and this may also affect the alpha counting significantly. A method based on the activation of uranium in a flux of thermal neutrons, followed by the recording of fission fragments, would allow measurements of uranium quantities as low as 10 nanograms. This method is as sensitive as neutron activation followed by delayed neutron counting, or neutron activation followed by gamma spectrometry, and is likely to be less expensive.

It is anticipated that this study will demonstrate the feasibility and cost effectiveness of neutron irradiation/fission fragment recording as a routine method for measuring uranium-bearing dust in filters from personal air samplers.

Proponent	REPD, UFD
Technical Advisor/Evaluator	REPD (S. Ching), UFD (R. McCabe)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$70k	$15k	$0k	$85k

Earlier Directly-Related Contracts and Funding:

4.136.1 Representativeness of Open-Face Dust Samples

It is proposed to determine the collection efficiency of open-face filters used as dust samplers. The collection efficiency will be determined under various sampling conditions and dust particle sizes. This type of equipment is used routinely in uranium mine and mill facilities to measure the concentration of radioactive long-lived dust in air.

The accurate determination of radioactive long-lived dust concentration in the working environment is necessary in order to evaluate the contribution of this pollutant to the total annual radiation dose received by the workers. In facilities where high-grade ore is extracted or processed, or even in low-grade facilities, long-lived radioactive dust may be a major contributor to the total annual radiation dose. It is, therefore, critical that dust concentrations be measured with an acceptable accuracy. The collection efficiency of dust particles in an air stream is a function of the air stream velocity, dust particle diameter, filter holder diameter, sampling head flow rate, and the orientation of the filter relative to the air stream. Under certain conditions, the collection efficiency of particles with diameters typically found in mines and mills may be lower than 50%. Since the activity of a particle is proportional to the cube of its diameter, a low collection efficiency for large particles may result in a large underestimation of radioactive dust measurements. To date, the collection efficiency of sampling equipment and the sampling procedures used by the uranium industry have not been thoroughly tested. As a consequence, the AECB is not in a position to evaluate, with confidence, the contribution of long-lived dust to the total annual radiation doses to workers.

The results of this study will indicate the sampling efficiency of currently used dust monitoring equipment for a range of dust particle sizes, air stream velocities, and filter-holder orientation. The gathered information will enable the AECB staff to interpret dust measurements taken in uranium mines and mills.

Proponent	UFD, HES
Technical Advisor/Evaluator	
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

5.127.2 Radionuclide Concentrations in Fish: Phase 2 (Detailed Analyses)

It is intended to continue to determine the concentrations of radionuclides (uranium, thorium, polonium, and lead) in fish and in the associated water and sediments, taken during the Phase 1 program, from the fish-stocked lakes found downstream of the Elliot Lake uranium mines in the Serpent River Basin. Further, it is intended that transfer parameters be calculated for each radionuclide (from sediments to water to fish to consumer).

Transfer parameters for the uranium and thorium decay series in aquatic ecosystems are important components in the estimation of public dose arising from uranium mining activities. Results of a recent report, 'Survey of Data on the Radionuclide Content of Fish in Canada' INFO 0231-1, indicated that there were very few studies of radionuclide concentrations in fish and their habitats (water and sediments) which have been conducted in Ontario or elsewhere. This project is proposed because additional data would be very useful to estimate more accurately the dose to the public resulting from consumption of fish in the Elliot Lake area, an area which accounts for all of Ontario's uranium production.

It is anticipated that the results of this study will provide reliable information to assess the dose from ingestion of fish by people in the Elliot Lake area.

Proponent	WID, REPD
Technical Advisor/Evaluator	WID (B. Zgola), REPD (T. Tostowaryk)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	Laurentian University
Principal Investigator	Dr. F.V. Clulow
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$30k	$30k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

5.127.1	$51,000

5.129.1 Decommissioning of Open Pit Mines - Literature Survey

It is proposed to conduct a literature survey of regulatory requirements for the decommissioning of all open pit mines, irrespective of the exploited mineral resource. The study would therefore include both uraniferous and non-uraniferous deposits.

This study is proposed because there are several open pit mines in Saskatchewan that will be decommissioned within the next year or two. These mines contain arsenic and nickel as well as uranium and it is desired to know what has been required by regulatory bodies and what has been done to effect decommissioning in the past.

It is anticipated that the results will be used to aid the AECB in assessing approaches and strategies for decommissioning proposed by licensees.

Proponent	WID
Technical Advisor/Evaluator	WID (R. Maloney)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

5.137.1 Study of Radionuclides in the Lichen-Caribou-Man Food Chain

It is intended to continue to study the transfer of uranium series radionuclides (specifically, polonium-210 and lead-210) in the lichen-caribou-man food chain, in northern Saskatchewan and the Northwest Territories, in order to determine transfer coefficients and bio-concentration factors for these two radionuclides in this environmental pathway.

One of the areas of uncertainty regarding the impact of uranium mining is the distribution of radionuclides, in the terrestrial environment, and the subsequent movement of these radionuclides in food chains leading to man. This is of particular concern in the subarctic and arctic, where the deposition of contaminants can be widespread and the concentration in food chains significant. This possibly significant accumulation may be due to the simplicity of arctic food chains, the longevity of vital parts of the food chain and the efficiency of accumulation of contaminants by vital parts of the food chain (particularly the lichens). There has been little work on uranium series radionuclides in these climatic regions. Because of increased mining developments in Saskatchewan, and a proposed uranium mine in the Northwest Territories near Baker Lake, the question of the significance of the terrestrial pathway for uranium series radionuclides to man is current and pressing. Therefore it is important to study transfers and bio-concentrations of polonium-210 and lead-210 in the lichen-caribou-man pathway. Polonium is chosen because of its radiotoxicity and propensity to concentrate in soft tissue, and lead-210, to establish the ratio between the two radionuclides.

It is anticipated that the results of this study will help AECB staff to evaluate the submissions on impact to the environment and to man, prepared by uranium mining licensees. (Joint funding has been obtained from Environment Canada and the Dept. of Indian Affairs and Northern Development.)

Proponent	REPD, WID
Technical Advisor/Evaluator	REPD (T. Tostowaryk), WID (B. Zgola)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	University of Saskatchewan
Principal Investigator	Drs. J.W. Sheard and S. Swanson, Ms. P.A. Thomas
Category	0

Past	91/92	92/93	93/94	Future	Total
$15k	$40k	$10k	$0k	$0k	$65k

Earlier Directly-Related Contracts and Funding:

5.143.2 Radiological Impact of Uranium Mining: Northern Saskatchewan - Phase II

It is proposed to continue to: a) reassess the regional radiological impact of uranium mines currently operating, being decommissioned, or abandoned in northern Saskatchewan; and b) estimate the additional regional radiological impact of uranium mining in northern Saskatchewan that may result once all presently proposed mines are operational.

In 1986, Environment Canada and the AECB published a report entitled "An Assessment of the Radiological Impact of Uranium Mining in Northern Saskatchewan". The context of the report was the uranium mining situation in the mid-1980's, and many of the source terms and other necessary parameters used to calculate the radiological impact were taken from the literature or were estimated. The present project is proposed because the former report was limited to the consideration of operational mines at the time (Key Lake, Rabbit Lake, Cluff Lake) in northern Saskatchewan, and did not address the abandoned mines or mines undergoing decommissioning in the Lake Athabasca region. Since 1986 there have been several changes in the operational sites: existing mines have been mined out and new ones have been or are being developed. In addition, extensive monitoring programs and research projects have been undertaken during this period. In view of these new developments and public interest both locally and province wide, it would be of use to the AECB to reassess the regional impact of uranium mining in northern Saskatchewan and obtain an estimate of the radiological impact when all proposed mines are operating.

It is anticipated that estimates of the combined regional impact of all the facilities, proposed and operational, will be of use as a benchmark by AECB staff in assessing the mitigating measures taken by the existing facilities and those proposed by the new facilities. (Cost-sharing for this project will be sought from Environment Canada.)

Proponent	WID
Technical Advisor/Evaluator	WID (B. Zgola), REPD (L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

5.144.1 Groundwater Inflow into Deep Underground Mines - Phase I

It is intended to carry out a two-phase study of the geological, hydrogeological, geochemical and geotechnical conditions at deep underground excavations located on the Canadian Shield. The study will involve a literature search to obtain information on deep underground mines with special emphasis on groundwater inflow into the mines as a function of time, depth and stress conditions. The study should consider the mines with underground openings at depths in excess of 500 meters, irrespective of the rock types and the ore mined.

This study is proposed because groundwater flow is recognized as the dominant factor for radionuclide release and transport from a repository to the biosphere. Due to limitations of the site investigation methods the assessment and the long-term predictions of the hydrogeological conditions in a repository will be diffitult. In order to increase the confidence in these assessments, it is believed that studies of deep underground mines could be helpful, because they can provide additional perspective and support for the possible conditions that could exist in a repository.

It is anticipated that the results of this study will be used in the review of the Canadian Nuclear Fuel Waste Management Program and as a support to AECB input in the Concept Review.

Proponent	WID
Technical Advisor/Evaluator	WID (V. Poliscuk)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$10k	$40k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

5.144.2 Groundwater Inflow Into Deep Underground Mines - Phase II

It is proposed to carry out the second phase of a two-phase study of the geological, hydrogeological, geochemical and geotechnical conditions at deep underground excavations located on the Canadian Shield. The study will be undertaken in the field and will examine conditions in deep underground mines with special emphasis on groundwater inflow into the mines as a function of time, depth and stress conditions. The study should consider mines with underground openings at depths in excess of 500 meters, irrespective of the rock types and the ore mined.

This study is proposed because groundwater flow is recognized as the dominant factor for radionuclide release and transport from a repository to the biosphere. Due to limitations of the site investigation methods the assessment and the long-term predictions of the hydrogeological conditions in a repository will be difficult. In order to increase the confidence in these assessments, it is believed that studies of deep underground mines could be helpful, because they can provide additional perspective and support for the possible conditions that could exist in a repository.

It is anticipated that the results of this study will be used in the review of the Canadian Nuclear Fuel Waste Management Program and as a support to AECB input in the Concept Review.

Proponent	WID
Technical Advisor/Evaluator	WID (V. Poliscuk)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$150k	$0k	$190k

Earlier Directly-Related Contracts and Funding:

5.144.2	$10,000

5.146.1 Thermal Consolidation Effects Around a High Level Waste Repository

It is intended to design and construct a lab-scale model (2 m x 2 m x 2 m) of a HLW repository and record its thermal-mechanical-hydrological behaviours.

AECB staff is assessing the Canadian concept of high level waste disposal. As part of this assessment, we are examining the the significance of coupling between thermal, hydrological and mechanical processes on the performance of the repository. The theory describing this coupling is called thermal consolidation. Staff has recently completed a literature review, and performed a mathematical simulation of thermal consolidation near a repository. Some preliminary conclusions can be drawn from the above work; nevertheless, to gain more confidence in the mathematical models used, a laboratory experiment should be performed to validate them.

The results of this project would be used to perform validation of AECB's mathematical models of thermal consolidation and provide data to improve these models if necessary.

Proponent	WID
Technical Advisor/Evaluator	WID (S. Nguyen)
Project Manager	J.K. Pereira
Review Panel	
Contractor	Selvadurai, P.
Principal Investigator	Dr. P. Selvadurai
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$35k	$0k	$0k	$55k

Earlier Directly-Related Contracts and Funding:

5.147.1 Assessment of the Underground Disposal of Tailings Concept

It is proposed to determine if the concept of underground disposal of tailings, produced from the milling of uranium ore, is practical, and assess the impact of removing the tailings from their current location on the surface and returning them to the mine.

Currently in the Elliot Lake area several mines are closing down and beginning the process of decommissioning. During the operational life of these mines, the tailings resulting from the milling of uranium ore have been placed on the surface and contained within a system of dams. One of the options for decommissioning these tailings areas is to return at least some of the tailings to the underground portions of the mine. In order to assess proposals of this nature made by the licensee, there is a need to understand the implications and impacts of this decommissioning approach.

The results of this project will be used to assess the decommissioning approaches proposed by the licensee.

Proponent	WID
Technical Advisor/Evaluator	WID (B. Zgola, R.J. Maloney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

5.148.1 Reassessment of the Deep Lake Disposal of Uranium Tailings

It is proposed to re-evaluate and update a previous study on the disposal of uranium tailings in deep lakes (INFO 0070, 1982), to determine if it is a practical approach and also to assess the impacts of both removing the tailings from their current location and placing them into a deep lake.

Currently, in the Elliot Lake area, several mines are closing down and beginning the process of decommissioning. During the operational life of these mines, the tailings resulting from the milling of uranium ore have been placed on the surface and contained within a system of dams. One of the possible options to decommission these tailings areas is to place the tailings at the bottom of a deep lake. In order to assess proposals of this nature, made by the licensee, there is a need to understand the implications and impacts of this decommissioning method.

The results of this project will be used to assess the decommissioning approaches proposed by the licensee.

Proponent	WID
Technical Advisor/Evaluator	WID (B. Zgola, R.J. Maloney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

5.149.1 Radiological Impact of Uranium Mining: Ontario

It is intended to assess the combined regional radiological impact of operational, non-operational, and idle mines in Ontario and the contribution of each site to that impact.

Currently there is insufficient information on either the combined regional radiological impact of facilities in all stages of their life cycle, or the contribution of each facility to the overall impact.

It is anticipated that the results of this study will enable a decision to be made on whether there is a need for mitigative measures at individual sites to be identified, and will enable the assessment of the efficacy of any proposed mitigative measures in terms of the combined radiological impact.

Proponent	WID
Technical Advisor/Evaluator	WID (B. Zgola, R.J. Maloney), REPD (L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$10k	$60k	$30k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

5.143.1	$40,000

5.150.1 Concentrations of Radionuclides in Wild Rice

It is proposed to measure the concentrations of radionuclides (e.g., uranium series) in wild rice, and in the associated water and sediments from regions of uranium mining and milling in Canada. Further, it is proposed that transfer parameters be calculated for each radionuclide from sediment to water to wild rice to consumer.

Transfer parameters for the uranium series in aquatic ecosystems are important components in the estimation of public dose arising from uranium mining activities.

It is anticipated that the results of this study will provide reliable information to determine the significance of this pathway.

Proponent	REPD
Technical Advisor/Evaluator	REPD (T.Tostowaryk), WID (R. Maloney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

5.152.1 Effects of Low-Level Radiation on Fish - Phase I

It is proposed to carry out a literature review on the subject of sub-lethal biological (molecular, cellular, tissue/organ and organism level) and ecological (population level) effects on fish, resulting from chronic exposure to low-level radiation. The review is to be placed in the context of fish species found in aquatic environments typical to those which receive waste discharges from nuclear facilities in Canada, and in the context of contaminants contained in these discharges (e.g., uranium and thorium decay chain nuclides, tritium).

Fish are considered to be a socially-valued species within aquatic ecosystems, in addition to having potential commercial and recreational value. However, questions have recently arisen in the public about the possible effects of waste discharges from nuclear facilities on fish, at both the individual and the population level. The understanding and quantification of the effects of low-level radiation on the non-human environment is an issue in radiobiology, and in assessments of the environmental impact of nuclear facilities by AECB staff. An understanding of the potential biological and ecological effects on species other than humans is essential in the development of regulatory criteria for protection of the environment.

The results of this study will assist the AECB in evaluating potential effects on fish due to discharges from nuclear facilities. It will also assist in determining if additional regulatory guidance or criteria are needed. The study will indicate whether follow-up studies, such as laboratory and field studies, are required to determine maximum dose rates to fish in the vicinity of selected nuclear facilities.

Proponent	REPD
Technical Advisor/Evaluator	REPD (L. Chamney)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

6.104.2 Production of a Hospital Radiation Safety Officer's Handbook - II

It is proposed to fund the revision of section B of the completed AECB sponsored project entitled: "Hospital Radiation Safety Officer's Handbook".

This work is proposed because the AECB has recently introduced several regulatory changes that affect the information contained in section B of the completed "Hospital Radiation Safety Officer's Handbook". Examples of regulatory changes and proposed changes include the consultative document C-122, entitled: "Proposed Amendments to the Atomic Energy Control Regulations for Reduced Radiation Dose Limits Based on the 1990 Recommendations of the ICRP", the forthcoming document on the application of ALARA and the revisions to the regulatory document R-52, entitled: "Design Guide for Basic and Intermediate Level Radioisotope Laboratories".

It is anticipated that the inclusion of new information in section B of the "Hospital Radiation Safety Officer's Handbook" will bring it up to date and allow the AECB to distribute this long-awaited handbook.

Proponent	RTD, REPD, HES
Technical Advisor/Evaluator	RTD (R. Irwin), REPD (G.W. Brown)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

6.104.1	$30,000

6.113.1 Study of Radioisotopes in Municipal Waste Disposal Systems

It is intended to measure, in the city of Hamilton, Ontario, the concentrations of radioisotopes in sewer, landfill and incineration systems, arising from the disposal of radioactive waste.

This project is proposed to verify, with field measurements at various municipal sites, the validity of the theoretical model for calculating collective and individual doses arising from the disposal of radioactive materials. This model is the result of a previous research project entitled: "Determination of the Radiological Impact of Radioisotope Waste Disposal", (INFO-0166).

It is anticipated that the results of this study will provide information concerning the limitations of the model discussed above. This model is to be used by AECB staff for compliance purposes.

Proponent	RTD, WID, HES
Technical Advisor/Evaluator	RTD (R.A. Chamberlain), WID (A. Regimbald), REPD (T. Tostowaryk), REPD (K. Bundy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$50k	$0k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

6.117.1 Radioisotopes Reference Manual & Data Base

It is proposed that a comprehensive but relatively non-technical data base and "pocket" reference manual be prepared covering all radioisotopes and radioisotopic compounds of commercial or health and safety interest in Canada. On one page or its equivalent would be found such information as physical characteristics: half-life, type(s) of radiation and relative abundance of each of them, radioactivity/mass relationship, degree of hazard - toxicity and radiation field (dose rate on contact and at 1 m for typical quantities), physical appearance and characteristics (solid, liquid, powder, colour, etc.), etc. The use(s) of the different compounds will also be indicated. The information could be prepared with reference to such existing documentation as the "Vade Mecum du Technicien Nucléaire" (Vol. II - Table des Caracteristiques), and product monographs from radioisotope suppliers.

One of the first questions the AECB is usually asked when an incident involving radioisotopes occurs, is "how dangerous is it?". Another concerns physical dimensioning - does the curie/TBq figure mean micrograms or tonnes? There is no handy, easily browsed source of this type of information, and it can reflect badly on the Board when answers to such apparently simple questions are not provided quickly and precisely.

The manual/data base would be used primarily by AECB staff in the Radioisotopes and Transportation Division, and the Office of Public Information. The portable manual would also be an invaluable aid to the AECB Duty Officer, Transport Canada's dangerous goods office, and emergency services such as police and fire authorities right across the country. A copy in the editorial office of all major news outlets would contribute to responsible media coverage of radioisotope incidents, as well as increase the AECB's visibility.

Proponent	OPI
Technical Advisor/Evaluator	OPI (H. Spence), REPD (F. Horvath), RTD (R. Chamberlain)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$15k	$0k	$55k

Earlier Directly-Related Contracts and Funding:

6.118.1 Assessment of Tc-99m Bioassay in Medical Work Environments

It is intended to investigate the frequency and magnitude of Tc-99m internal radioactive contamination among workers in medical environments. Identification and selection of an affordable instrument for the Tc-99m bioassay screening program will be performed. The work will be conducted in nuclear medicine hospitals and radiopharmacies.

This project is proposed because the AECB has not previously investigated, in detail, the potential intake of Tc-99m by workers in medical work environments. In addition, there is a need to identify an affordable instrument capable of detecting Tc-99m according to the requirements of "Bioassay Guideline 5 - Guideline for Tc99m Bioassay".

It is anticipated that the result of this study will provide information to AECB staff to determine the requirements for routine Tc-99m bioassay and a suitable bioassay instrument for workers in the nuclear medicine and radiopharmaceutical environments.

Proponent	RTD
Technical Advisor/Evaluator	RTD (R. Brown), REPD (F. Horvath)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$75k	$30k	$0k	$125k

Earlier Directly-Related Contracts and Funding:

6.119.1 Occupational Radiation Doses to Health Care Workers

It is proposed to conduct a study of the occupational radiation doses received by health care workers who, as part of their jobs, visit patients (e.g., hospital out-patients, patients recently released from hospital) in their homes for various medical reasons.

Some patients, for medical purposes, have received radionuclides into their bodies. People who come close to such patients may, therefore, receive radiation doses from them until the radionuclides have been eliminated. Since health care workers can be in such proximity to patients during home visits, they may, depending on how frequently they visit radioactive patients, receive annual occupation radiation doses which may not be negligible. In order to establish whether the health care workers know if their patients are radioactive, what precautions (if any) they take if they do know that their patients are radioactive, what training (if any) they receive on this matter and what radiation doses are typically received by them, it is important to carry out this research project.

The results of this study will include a quantification of the doses received by health care workers in the performance of their duties as well as a description of their work habits in the presence of radioactive patients. Based on this information, work techniques will be recommended, as necessary, in order to help protect the health care workers from ionizing radiation. The result will be a general reduction of occupational radiation doses for health care workers (ALARA).

Proponent	REPD
Technical Advisor/Evaluator	REPD (G. Poirier)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$45k	$0k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

6.120.1 Doses from Industrial Radiographic Exposure Devices

It is proposed to initiate a study to determine the fractionated doses received by trainees and qualified operators of industrial radiographic exposure devices while performing the various tasks in radiography and under varying working conditions.

This study is proposed because AECB radiography licensees employ over 1,500 trainees and qualified operators and currently these employees, as a group, have been recorded as one of the most highly exposed groups of atomic radiation workers in Canada. The AECB is concerned about the recorded high doses received by this group of workers and proposes to carry out this investigation by splitting the procedure of a radiography job into its basic elements by recording the respective doses received by workers.

It is anticipated that the results of this study will provide information, to the AECB and to operators of radiographic exposure devices, as to how to reduce annual radiation doses to workers by improving the radiation protection safety practices of each phase of the job.

Proponent	RTD, REPD, HES
Technical Advisor/Evaluator	RTD (M. Wood), REPD (L. Gourgon), HES (K.P. Ho)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$30k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

REGULATORY RESEARCH AND SUPPORT PROGRAM 1992/93

7.093.1 Epidemiology of Lung Cancer Mortality in Canadian Mining Communities

It is intended to continue funding the ongoing case-control pilot study of lung cancer deaths in uranium and non-uranium mining towns across Canada in which lung cancer mortality has been shown to be significantly elevated.

The study is being carried out in order to attempt to find out to what extent various factors in the home and the workplace were responsible for excess cancer among miners and other residents of mining communities.

It is anticipated that the results of this study will be used to improve risk estimates for radiation-induced lung cancers. (This is a joint study with Statistics Canada and Health and Welfare Canada.)

Proponent	REPD, HES, NHW (D. Wigle), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	REPD (S. Ching, C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	Health & Welfare Canada
Principal Investigator	Y. Mao
Category	0

Past	91/92	92/93	93/94	Future	Total
$70k	$0k	$3k	$0k	$0k	$73k

Earlier Directly-Related Contracts and Funding:

7.093.2 Epidemiology of Lung Cancer in a Canadian Mining Community

It is proposed to resume a case-control epidemiological study of lung cancer mortality in Canadian mining communities, initiated in Timmins, Ontario, in 1984 (project 7.093.1).

The original study was undertaken in order to identify the hazards responsible for an elevated (relative to the provincial average) incidence of lung cancer in the community. The main factor of risk being studied is long-term exposure to indoor radon daughters. The preliminary analysis of the earlier study showed a lack of correlation between 90 cases of lung cancer and domestic exposure to radon daughters. It is now proposed to study an additional 75 cases of lung cancer, and to double the number of controls for each case. The residential history of cases and controls will be traced back as far as possible.

It is expected that the results of this study will be used to reduce uncertainties in risk estimates for radon daughter-induced lung cancers, especially at low exposures. (This study will be co-funded equally by Health and Welfare Canada and the AECB.)

Proponent	REPD, HES, NHW (D. Wigle)
Technical Advisor/Evaluator	REPD (S. Ching, C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$45k	$30k	$45k	$120k

Earlier Directly-Related Contracts and Funding:

7.093.1	$73,000

7.106.2 Effects of In Utero Exposure on Central Nervous System

It is intended to continue funding a full-scale study of the health effects on the central nervous system (CNS) of experimental animals (mammals) following in utero exposure to ionizing radiation. Pregnant animals will be exposed to different doses and dose rates of ionizing radiation at different stages of gestation and the corresponding morphological and physical changes in the brain will be assessed quantitatively.

It is anticipated that an increasing number of young women will seek employment in the Canadian nuclear industry, where, in some cases, exposure of embryos or foetuses may occur. Very little information is available in the literature about the effect of in utero irradiation on the development and structure of the central nervous system. A feasibility study (84.8.8) completed in 1986 recommended a full-scale study to make quantitative estimations of the risk of health defects on the CNS following in utero irradiation taking dose, dose rate, and the stage of gestation into account.

The results of the full-scale study will be used to extrapolate, from animals to humans, the risk estimates for radiation-induced developmental defects. (This is a joint study between the University of Manitoba, the University of California (Davis) and the AECB on an equal cost-sharing basis.)

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	01
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$10k	$40k	$60k	$199k	$309k

Earlier Directly-Related Contracts and Funding:

84.8.8	$22,000

7.116.1 Cancer Morbidity Follow-Up Feasibility Study

It is proposed to determine the feasibility of using computerized record linkage with national cancer incidence data available in Canada for individual medical follow-up studies by attempting to link the National Dose Registry with the Alberta Cancer Registry and to determine any association between occupational radiation exposure levels and cancer incidence. This would be of particular assistance in developing the potential future use of the Canadian Cancer Data Base.

This feasibility study is proposed because cancer data will greatly assist the AECB in determining whether any excessive cancer risks exist due to exposure to certain potentially hazardous environmental, occupational or other factors. This information will both complement and supplement mortality data available through the Canadian Mortality Data Base by providing a more sensitive measure (than mortality data alone) of the differences in risk from exposure to potentially hazardous environmental, occupational or other factors and a possible earlier detection of cancer. It will allow for earlier preventive measures to be introduced in the workplace for current as well as future employees.

It is anticipated that this study will provide the AECB with: (i) the ability to draw upon more cancer data from Canadian sources; and (ii) the opportunity to detect the occurrence of any non-fatal or rare cancers. In addition, it will assist the AECB in identifying areas of occupational, environmental, and other cancer risk. It will aid the AECB in its regulatory activity, and will also help in providing information for the assessment of exposures and occupational hygiene practices.

Proponent	REPD, HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	REPD (C. Pomroy, S. Ching)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$30k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

7.117.1 Hospital Record-Keeping System for Epidemiological Studies

It is intended to continue a feasibility study to modify hospital record-keeping systems to facilitate inexpensive case-control epidemiological studies of radiation-induced cancers.

Case-control studies of radiation-induced cancer can be conducted inexpensively using hospital records. However, the record-keeping systems in Canadian hospitals are not currently in a format that facilitates such studies.

It is anticipated that the results of the study will determine the feasibility of modifying hospital record-keeping systems to facilitate epidemiological studies. If the modification is feasible, several epidemiological studies of radiation-induced health effects can be conducted inexpensively to improve the accuracy of risk estimates. (NHW and provincial ministries of health are co-opearting in the project.)

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (C. Pomroy, K. Bundy)
Project Manager	K.P. Ho
Review Panel	02
Contractor	University of Ottawa
Principal Investigator	Raman, Dr. S.
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$30k	$20k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

7.122.2 Expanded Cancer Incidence Linkage for the Canadian Study of Cancer following Multiple Fluoroscopies

It is intended to expand the cohort study entitled "Computerized Linkage of National Cancer Incidence Data Base", Project 7.122.1, in order to examine further the relationship between exposure to low-LET radiation from multiple fluoroscopies and the risk of breast, lung and thyroid cancers in a cohort of 93,192 Canadian tuberculosis patients first treated in Canadian institutions between 1930 and 1952. The present proposal is to expand the cancer incidence data base to include cancer incidence data for all the years between 1970 and 1987 (in Project 7.122.1, the cancer incidence data base included the years 1975-1983), and to relink the records from the tuberculosis cohort to the expanded data base.

The expansion of the cancer incidence data base will double, approximately, the number of years for which cancer incidence was available for the cohort study, and this should provide a substantial increase in the power of the subsequent statistical anlaysis. Using national age-specific cancer incidence rates and the breast cancer risk model derived by the BEIR V Committee, it is estimated that a total of 897 cases of breast cancer would be identified among the females in the tuberculosis study by expanding the linkage to include the years of 1970 to 1987. The expanded cancer incidence would also be of direct relevance to the computation of risk with respect to the incidence of both lung and thyroid cancers in relation to radiation exposure.

The results of this expansion will have a direct impact in improving the risk models for breast, lung, and thyroid cancers due to multiple chest fluoroscopies. In addition, the developed cancer incidence data base will be of considerable value for other on-going and planned epidemiological studies related to radiation and cancer risk studies in Canada. (This is a joint project with Statistics Canada and the National Cancer Institute of Canada, which will each contribute $20k to the project.)

Proponent	REPD, HES, NCIC (G. Howe), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	National Cancer Institute of Canada
Principal Investigator	G. Howe
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$12k	$18k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

7.122.1	$120,000

7.127.1 Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens

It is proposed to investigate the feasibility of using a flow cytometry method for measuring radiation damage in fresh (recently extracted) human lymphocytes, and to measure the damage produced by a combined exposure to radiation, delivered at doses in the occupational range, and to chemical carcinogens.

This project is proposed because currently there is uncertainty as to whether radiation and chemical insults act synergistically, independently, or whether the chemical carcinogens influence a cell's response to radiation insult. This project is intended to be an appropriate follow-on to 7.107.1, "A Feasibility Study on the Identification and Determination of Exposure Levels of Non-Radiological Carcinogenic Substances at Canadian Nuclear Facilities", as it will provide experimental evidence of synergism or lack thereof.

It is anticipated that the findings of this study will assist AECB staff in quantifying the modifying influences of chemical carcinogens on the responses of workers to occupational radiation exposure. (This project is proposed to be funded jointly with AECL. AECL and the AECB will each contribute 50% of the cost of the project for a total of $146K.)

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$48k	$25k	$0k	$73k

Earlier Directly-Related Contracts and Funding:

7.128.1 The Relative Impact of Radiation-Induced Genetic Disorders

It is proposed to fund a study to determine the relative impact of different types of radiation-induced serious genetic disorders in terms of their respective loss of years of life expectancy by linking the B.C. Health Surveillance Registry Records with the Canadian Mortality Data Base.

The study is proposed because the relative impact of different types of serious genetic disorders can only be compared on a common scale, such as in terms of their respective contribution to loss of years of life expectancy. To date, no comprehensive study has been done, in the Canadian context, to derive the relationship between different types of genetic disorders and their corresponding loss of years of life expectancy. The data base at the B.C. Health Surveillance Registry is considered to be a leading source in North America for such a complex analysis.

It is anticipated that the results of the study will enable the AECB to compare, on a common scale, the relative impact of different types of radiation-induced genetic disorders. Initiation of this study is awaiting the review of 7.109.1. (This is proposed to be a joint study with B.C. Ministry of Health and Statistics Canada, with AECB contributing 70% of the total cost.)

Proponent	REPD, UBC (S. Sheps), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$45k	$45k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

7.133.1 Bone Cancer from Radionuclide Intake

It is proposed to conduct an epidemiological study of bone cancer incidence among Canadian children and young adults exposed to radium and other bone-seeking radionuclides in drinking water and food. In the first phase of the study, radium and other bone-seeking radionuclides in typical milk and food samples, obtained from areas where well water was used for irrigation purposes, is to be measured. In a subsequent phase, a detailed case-control study of bone cancer incidence, in relation to total radium and other radionuclide intake, is to be investigated.

A preliminary study of bone cancer incidence among Ontario residents has identified a suggestive association between the incidence of excess bone cancer and exposure to concentrations of radium, in well water, which were higher than the provincial average. Although the level of radium in the well water used by those who contracted bone cancer was less than the National Health & Welfare-recommended maximum concentration of 1 Bq/L, the total intake of radium and other radionuclides, mainly dietary intake, should be measured to derive a relationship between the total intake of these radionuclides and the incidence of bone cancer.

The results of this study are expected to provide a quantitative relationship between excess bone cancer and the intake of total radium and other radionuclides. (This is expected to be a joint study with NHW, Ontario Ministry of Labour (OML), Ontario Ministry of the Environment and the Ontario Cancer Treatment and Research Foundation (OCTRF) at a total cost for both phases of $900K, of which the AECB portion would be about $120K, approximately $60K of which is expected to be for Phase I and the balance for Phase II.)

Proponent	OCTRF, REPD, OML (M. Finkelstein)
Technical Advisor/Evaluator	REPD (F. Horvath, C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$40k	$40k	$120k

Earlier Directly-Related Contracts and Funding:

7.135.1 Mechanism of Radiation-Induced Mental Retardation

It is intended to continue funding laboratory experiments to study the effect of low doses of ionizing radiation on the migratory characteristics of neurons in mice and in non-human primates. Embryonic neural cells will be cultured, and exposed to different doses of ionizing radiation at different stages of neuronal development. The subsequent changes in the cellular surface structures, the number of cells present to migrate and the rates and the extent of migration of the neurons will be assessed quantitatively using a variety of monoclonal antibodies.

Recently, magnetic resonance imaging and autopsy data have established that a substantial fraction of the radiation-related cases of mental retardation seen in Hiroshima and Nagasaki bomb survivors exhibits evidence of a gross impairment of neuronal migration, seen as ectopic grey matter, largely circumventricular in distribution. It is important to understand the relationship between exposures and impaired migration and the cellular and molecular nature of this impairment in order to derive a quantitative value for the risk of mental retardation following in utero exposure to ionizing radiation.

It is anticipated that the results of this study will provide quantitative information on the mechanism of the impairment of the neuronal migratory processes. This understanding will lead to a better estimate of the risk of mental retardation due to in utero exposure to ionizing radiation. (This is a joint study with the Radiation Effects Research Foundation of Japan, Kyoto Prefectural University of Medicine (Japan), and the University of Texas Health Sciences Center in Houston. The total cost of the project is about $280k, shared among all sponsors, with an AECB contribution of about $80k over 3 to 4 years.)

Proponent	REPD, HES, U. of Texas (W. Schull), Kyoto University
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	01
Contractor	Schull, W.J.
Principal Investigator	Prof. William J. Schull
Category	0

Past	91/92	92/93	93/94	Future	Total
$15k	$15k	$20k	$30k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

7.137.1 Study of Childhood Cancer following Maternal X-Irradiation - Phase 1

It is intended to assess the feasibility of determining the incidence of childhood cancer among (i) those children who had abnormal delivery (such as breech presentation) or birth defects (such as Down Syndrome), but whose mothers were not subjected to irradiation during pregnancy, and (ii) those who received in utero exposure to X-rays, both groups to be compared with suitably selected control populations.

Some controversial studies have indicated an association between maternal exposure to low doses of ionizing radiation (i.e., at levels in the neighbourhood of regulatory dose limits) and the incidence of excess childhood cancers. On the other hand, some recent studies have reported an association between abnormal pregnancy cases (such as breech presentation and Down Syndrome) and excess childhood cancers, even in the absence of exposure to X-rays during pregnancy or delivery. It is therefore possible that the reported association between maternal irradiation and excess childhood cancer was essentially due to those cases of abnormal pregnancies and deliveries and not necessarily due to maternal irradiation.

The results of this study will demonstrate whether it is possible to improve our understanding of the qualitative association between childhood cancer and maternal irradiation and may improve the quantitative risk estimates for radiation-induced cancers. (The feasibility study will be followed, if justified, by a full-scale study.)

Proponent	REPD, HES, UBC (T.W. Anderson)
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	M. Lupien
Review Panel	02
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$10k	$30k	$25k	$0k	$65k

Earlier Directly-Related Contracts and Funding:

7.141.1 Response of Mice to Gamma Rays Delivered at Low Dose Rates

It is intended to expose CBA/H mice to Co-60 gamma rays at low doses (1 Gy, 0.1 Gy) and low dose rates (0.004 Gy/hr; 0.02 Gy/hr; 0.1 Gy/hr; 0.5 Gy/hr) and score the subsequent incidence of myeloid leukemia in the animal population.

The primary hazards of exposure to low levels of radiation at low dose rates are generally considered to be the induction of cancer and of genetic changes. For these end points a task group has recently observed, in ICRU Report No. 40, that the appropriate quality factors for gamma rays and x-rays have been derived almost exclusively from laboratory studies on particular end points, such as the induction of somatic mutations in micro-organisms (Tradescantia). Data obtained recently suggest that doses of gamma rays up to about 1 Gy, delivered at dose rates of about 0.008 Gy/hr, have comparatively little effect on the induction rate of mammary tumours in Sprague-Dawley rats. This finding suggests that the risk due to exposure to gamma rays that are delivered in low doses may decrease to zero at low dose rates for this particular end point. If this observation were confirmed, this could lead to a reduction of the quality factor for gamma radiation delivered at low dose rates, and therefore to a re-evaluation of risk estimates for radiation-induced cancers in humans from gamma radiation. Other studies that have the induction of cancers as their end points are required to investigate the risk of gamma rays when delivered at low dose rates.

It is anticipated that this study may provide justification for reducing the quality factor below the current value of unity for gamma rays delivered in low doses and at low dose rates. This would impact on the risk estimates for radiation-induced cancer for humans from exposure to gamma rays. (This project is being cost-shared wtih AECL on an approximate one-third (AECB)/two-third (AECL) basis with a total project cost estimate of $450k.)

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	06
Contractor	AECL Research - CRL
Principal Investigator	R.E.J. Mitchel, J.S. Jackson
Category	0

Past	91/92	92/93	93/94	Future	Total
$12k	$30k	$60k	$33	$0k	$135k

Earlier Directly-Related Contracts and Funding:

7.142.1 Mortality Analysis of the Fluorspar Miners from 1985-1990

It is intended to update the mortality analysis of the fluorspar miners in St. Lawrence, Newfoundland, from 1985 to 1989. The risk of lung cancer per unit exposure to radon daughters is being recalculated using the additional mortality information and previously estimated exposures to radon daughters.

The previous analysis considered lung cancer mortality only up to 1984. Since that time, more deaths have occurred among fluorspar miners as a result of the natural aging of this cohort. Since the fluorspar miners were in a unique situation, in which they were exposed to neither gamma radiation nor radioactive dust, it is important to analyze their mortality data to obtain improved risk estimates for lung cancer in a 'pure' radon daughter environment.

It is anticipated that the results of this study will further improve the risk estimates for lung cancer from exposure to radon daughters in the absence of gamma radiation and radioactive dust. (This is a joint project with the Department of National Health and Welfare and Statistics Canada.)

Proponent	REPD, HES, NHW (D. Wigle), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	REPD (C. Pomroy, S. Ching)
Project Manager	M. Lupien
Review Panel	
Contractor	Dept. of National Health and Welfare
Principal Investigator	Morrison, Dr. H.
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$25k	$15k	$10k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

7.091.1 $170,000

7.143.1 Canadian Cancer Data Base

It is proposed to link internally the Canadian Cancer Data Base file to identify multiple records of cancer incidence for the same individual. In addition, a set of microfiche of the Canadian Cancer Data Base will be created in various format sequences to facilitate manual checking of the results of the proposed study.

This approach is proposed in order to reduce the labour required when the cancer data files are being used in the follow-up of radiation studies. Past studies have included the fluoroscopy study, the Eldorado Nuclear Limited cohort, and Atomic Energy of Canada Ltd. study.

The results of this study will help to determine whether the occurrence of cancer, where radiation was present, is significantly higher in study groups exposed to radiation. (This project will be cost-shared with Statistics Canada. Statistics Canada is to contribute $10k and the AECB $20k.)

Proponent	REPD, HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

7.143.2 Development of a New 1951-1990 Master Identification File

It is proposed to prepare, at Statistics Canada, a new Master Identification File (MIF) 1951-1990 of the Canadian National Dose Registry for record linkage purposes.

The original National Dose Registry file used in the mortality study (Research project 7.101.1) included entrants up to December 31, 1983. The proposed work will add new members (approximately 500,000) who joined the workforce after the original cut-off date, plus any updates done on the 1951-83 entrants. The main identifier now used in the National Dose registry is the Social Insurance Number (SIN). The SIN should now provide an adequate means of ensuring that there is only one entry per person on the file. However, the linkage to either the Canadian Mortality Data Base or the Canadian Cancer Incidence Data Base is based on name identifiers. Thus, the National Dose Registry File will have to be pre-processed for any linkage to ensure that the records are adequate for a linkage and, if not, to take steps to correct the problems. The file will have to be checked to ensure that there is only one identifier record per individual. The resulting new MIF of the National Dose Registry will then be available for linkage to the Canadian Mortality Data Base or the Canadian Cancer Incidence Data Base.

The proposal to prepare the new Master Identification File to 1990 will allow the use of the complete National Dose Registry in assessments of risks associated with occupational exposure to radiation. (The Department of National Health and Welfare will contribute $40K in resources and person-years for the preparation of the Registry data, at Statistics Canada).

Proponent	REPD, HWC, Statistics Canada, HES
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$15k	$0k	$0k	$15k

Earlier Directly-Related Contracts and Funding:

7.143.1	$20,000

7.143.3 Linkage of National Dose Registry to the Cancer Incidence Data Base

It is proposed to link the 1951-1983 National Dose Registry (NDR) which contains radiation exposure data on some 300,000 Canadian workers to the Canadian Cancer Incidence Data Base and to analyse the results of the linkage.

The linkage of the National Dose Registry (1951-1983) to the Canadian Mortality Data Base (1951-1987) (Research Project 7.101.1) has been completed. The analysis steps are planned and will commence shortly. Since cancer is the end point of interest in this study, it is now proposed to examine the type of cancer in the registry entrants using the same 1951-83 NDR file that was used in the mortality linkage. Overall mortality from cancer is about 50%; however, five-year survival rates vary with the type of cancer ranging from less thant 10% for pancreas to approaching 100% for bladder cancer in certain age groups. To examine the possibility of radiation-induced disease it is, therefore, more accurate to look at cancer incidence rather than cancer mortality. The historic Canadian Cancer Data Base, which is in a form suitable for record linkage, will be utilized.

The results of this study will provide an estimation of risk of radiation-induced cancer in a Canadian occupational setting. This study will allow the examination of cancer incidence in different occupational groups such as industrial radiographers, nuclear medicine tehcnicians, X-ray technicians, etc., and other groups who have not previously been studied. It will provide information on the occurrence of rare and non-fatal cancers, and will help in the assessment of exposure and occupational hygiene practices. (This is a joint study with Statistics Canada who will also contribute 10K, and the Department of National Health and Welfare whose total contribution, including personnel and funds, will be about $118K.)

Proponent	REPD, NHW, Statistics Canada, HES
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$40k	$20k	$100k

Earlier Directly-Related Contracts and Funding:

7.143.1	$20,000
7.143.2	$15,000

7.148.1 The Combined Effects of Radiation and Chemical Substances

It is proposed to carry out an in-vitro experiment on human lymphocytes to investigate the combined effects of exposures to chemical subtances, at or near threshold limit value concentrations found at nuclear facilities, and ionizing radiation, delivered at doses in the occupational range.

This project is proposed because workers at Canadian nuclear facilities are exposed to chemical substances which may be potential factors in the induction of cancer among radiation workers. The interactions between exposure to radiation and chemical substances have not been accounted for in epidemiological studies. The nature of these interactions may be additive, antagonistic or synergistic. This project is proposed as a follow-on to the recently completed Project 7.107.1, "A Feasibility Study on the Identification and Determination of Exposure Levels of Non-Radiological Carcinogenic Substances at Canadian Nuclear Facilities", which provided a 'catalogue' of chemicals found in the workplace.

It is anticipated that this project will help to assess more accurately the health risks from exposure to radiation alone as compared to those from radiation interacting with chemical subtances. (AECL-CRNL is proposing to cost share this project with the AECB on a 50%-50% basis. The overall cost of this project is estimated to be $80k.)

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (F. Horvath, K. Bundy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$10k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

7.107.1	$46,000

7.149.1 Biological Dosimetry

It is proposed to examine a spectrum of biological indicators, such as cytogenetic and immunochemical changes in blood cells (e.g., formation of micronuclei), reactive products in DNA, protein, lipid and polysaccharides, and stable biophysical changes in biological samples (e.g. hair, teeth etc.), for their suitability for measuring the extent of inadvertent or accidental exposure of individuals, and their accumulation of chronic exposure to ionizing radiation. Phase 1 of the study will consist of a detailed review and critique of existing techniques of biological dosimetry (based on currently available literature), including an assessment of their sensitivity, accuracy, reproducibility of results, and other important parameters with respect to monitoring low-level radiation exposure. Phase 2 will consist of the development and testing of a prototype biological dosimeter to establish the dose-response relationship, dose-rate effects, effects of dissolved oxygen, other environmental effects of importance in a practical biological dosimeter, convenience of use, stability, sensitivity (including the influence of the prevalence of the biological indicators in unexposed individuals), reliability, reproducibility and overall efficacy.

This study is proposed because, for accidental exposure, biological dosimetry is often all that is available, and chromosome aberration analysis does not have sufficient sensitivity or accuracy. In addition, the possibility of using these new methods for determining cumulative dose over many years is of interest.

It is anticipated that the results of this study, i.e., the development of a practical biological dosimeter, will provide AECB staff with a means of assessing the dose to licensee staff who are accidently exposed to ionizing radiation, whether they are ARWs or not, and, in addition, possibly corroborate or refute anomalous dose data obtained from currently used personnel dosimeters. (The study is to be jointly funded by the AECB and AECL on an equal cost-sharing basis: AECB $100k, AECL $100k.)

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$30k	$30k	$100k

Earlier Directly-Related Contracts and Funding:

7.153.1 RBE of Tritium and Co-60 Gamma Rays at Low and High Dose Rates

It is intended to examine the effects of tritium beta-rays (from HTO) and Co-60 gamma-rays at "low" versus "high" dose rates, on both DNA repair-proficient and repair-deficient cultured mammalian cell lines. Two different biological end points (colony forming ability and induction of micronuclei), will be used. The results will be compared to those obtained with 200 kVp x-ray exposures at the same dose rates.

This project is being carried out because tritium beta-rays account for a significant portion of the total dose from the operation of CANDU nuclear generating stations, and the estimation of dose-rate effects is assuming ever increasing importance in radiation protection programs. Values of Relative Biological Effectiveness (RBE) for tritium, as reported in the literature, range from about one to two. However, much of this variation may arise as a result of dose-rate effects, and from the use of different biological end points for determining the RBE. It is necessary to obtain experimental data that will aid in the interpretation of the RBE values reported in the literature.

It is anticipated that the findings of this study will result in an improved understanding of the relationship between dose-rate effects and different end points used for determining the RBE for exposures to tritium and gamma-rays. This study will augment and extend the earlier study, 7.120.1 Cytogenetic Measurements of the RBE of Tritium, which focused on the induction of chromosomal aberrations and translocations in mouse cells. The results of the present study (and 7.120.1) will assist AECB staff in evaluating the biological significance of doses from tritium and gamma-rays delivered at different dose rates.

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath, C. Pomroy)
Project Manager	E. Rabin
Review Panel	
Contractor	AECL Research - CRL
Principal Investigator	D.P. Morrison
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$90k	$40k	$0k	$0k	$130k

Earlier Directly-Related Contracts and Funding:

7.160.1 Metabolism and Fetal Dosimetry of Tritium

It is proposed to conduct a series of experiments on pregnant rats to determine the uptake, distribution and retention of tritium and of organically bound tritium within the conceptus of rats following the ingestion of tritium. There will be two separate sets of experiments using: 1) tritiated water and 2) tritiated food. Additionally, the off-spring from these rats will be observed for leukemia incidence during their maturation.

Tritium is one of the major effluents released to the environment from CANDU reactor operations, and it is important to be able to assess realistically the committed doses received by the fetus following the ingestion of tritiated food and water by the mother. This project is proposed because in assessing the risks to the developing conceptus from exposure to tritium, many factors, such as tissue specific activity, location and metabolism of tritiated compounds, must be taken into consideration. Tritium can be incorporated into organic molecules within the cell, and into the nuclei of proliferating cells. Tritium incorporated in this way is retained in the body four times longer than that for tritiated water. Of particular importance, oocytes and latent stem cells of the hematopoietic system are long-lived tissues which may retain tritium at elevated concentrations. For the adult, the fraction of tritium incorporated into organic molecules, including DNA, is higher for tritium ingested in the form of tritiated food than for tritiated water, and results in a committed dose which is higher than that from tritiated water by a factor of about two (ICRP 56). Although little is known about the fate of tritium incorporated into the conceptus, evidence suggests that about six times as much tritium will be incorporated into the DNA of the developing conceptus in comparison to the adult.

It is anticipated that the findings from this project will enable AECB staff to evaluate more accurately the dose and subsequent risk to the fetus from uptake by the mother of tritiated water and food contaminated with tritium. The results of this study may impact on the application of the proposed amendment to the Atomic Energy Control Regulations that pertains to the dose limit to the fetus. (This is proposed as a joint project with AECL, Ontario Hydro and the Canadian Fusion Fuel Technology Project at a total cost of about $1000k, the AECB portion of which will be about $240k.)

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$60k	$80k	$100k	$240k

Earlier Directly-Related Contracts and Funding:

7.161.1 Literature Review: Interaction Radiation - Co-Carcinogens

It is proposed to conduct a review of the literature on the studies of combined effects of ionizing radiation and chemical carcinogens present in the work place on the induction and promotion of cancer.

Risk of radiation-induced cancer is usually confounded by the presence of chemical carcinogens present at the work place. It is not known how these agents interact in the induction and promotion of cancer. A better understanding of the extent and type of interaction between ionizing radiation and chemical carcinogens is necessary to improve the risk estimates for radiation-induced cancer. Although the information on the subject is scanty, it is important to carry out a detailed review of the literature before initiating any experimental study.

The results of this literature review will indicate to the AECB the potential of the co-carcinogenesis of radiation and chemicals, and will provide an indication of those chemicals for which additional experimental data are required to derive risk factors for co-exposures.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

7.162.1 Assessment of Biases Due to Measurement Errors on Risk Estimates

It is intended to develop an appropriate statistical methodology for assessing the effect of errors in radiation dose or exposure measurements on subsequent risk estimates, and to apply this methodology to quantify the effect of measurement errors on the risk estimates for radiation-induced leukemia, breast and other solid cancers.

The errors in estimating radiation exposures used in major epidemiological studies can introduce substantial biases into the risk estimates for radiation-induced cancers. A recent AECB-sponsored study, "The Selection and Use of Control Groups in Epidemiologic Studies of Radiation-Induced Cancers", Project 7.118.1, by the National Cancer Institute of Canada has concluded that measurement errors were likely to be the most important biases introduced into the risk estimates for radiation-induced cancers. To date, little or no attention has been given to dealing with these biases involved in risk estimates. For example, risk estimates reported in the recent BEIR IV and BEIR V reports did not take such measurement errors into account in estimating the risk of cancer due to low- and high-LET radiations. There have been a number of recent developments in the field of statistical methods to take into account measurement errors in making risk estimates, and this new information may be used to re-examine the errors associated with the risk estimates derived from Canadian and other major epidemiological studies of radiation-induced cancers.

It is anticipated that the results of this study will enable the AECB to understand the extent of the biases introduced by exposure measurement errors on currently-used risk estimates (which form the basis of the Canadian regulatory dose limits). Additionally, the study will provide the AECB with a detailed guide for addressing this problem in a number of AECB-funded, on-going and future, epidemiological studies of radiation-induced cancer and developmental disorders. (This project is expected to be a joint study with the National Cancer Institute of Canada, University of New Mexico, and the University of Southern California on an equal cost sharing basis. The cost to the AECB is expected to be about $62k.)

Proponent	REPD, NCIC, U. of New Mexico, U. of S. California
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	M. Lupien
Review Panel	
Contractor	NCIC Epidemiology Unit
Principal Investigator	Dr. Geoffrey R. Howe
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$10k	$52k	$0k	$0k	$62k

Earlier Directly-Related Contracts and Funding:

7.163.1 Alteration of Immune Surveillance and DNA Repair Capacity

It is proposed to carry out an *in vivo* study to investigate the effect of varying dose rate of gamma radiation on natural killer (NK) cell activity. The proposed study is twofold. First, groups of mice (CBA/H) will be gamma irradiated to a predetermined total dose but at decreasing dose rates. At a selected time after irradiation, NK cells from the spleens and the blood system of the irradiated mice will be isolated and the NK cell cytotoxic activity will be assessed in order to evaluate the immune surveillance capacity. In the second part, other groups of mice will be gamma irradiated at a low dose rate and to a predetermined total low dose. At a selected time after the chronic irradiation, these mice will be irradiated with a single, acute, high dose of gamma radiation. The cytotoxic activity of isolated NK cells from the acute gamma-irradiated mice will be compared with those NK cells in mice receiving a similar acute gamma radiation dose but without the low dose, chronic irradiation. The ability to perform repair of DNA damage will be monitored by radiation-induced strand breaks and base alkylation.

This project is proposed because, in order to estimate properly the risk associated with a radiation exposure, it is necessary to understand the influence of previous radiation exposure on the cellular capacity for DNA repair. Moreover, it has been known for some time that ionizing radiation depresses NK cell activity. This depression may increase the risk of radiation-induced leukemia, since experiments in rodents have shown that injection *in vitro* of cultured NK cells into irradiated mice reduce the risk of radiation-generated leukemia by about ten-fold. Because the activity of this immune surveillance system is obviously a major factor in determining the ultimate risk of radiation-initiated leukemia, it is important to understand how NK cell activity itself responds, *in vivo*, to radiation exposures delivered under conditions relevant to human exposure, that is, as split doses or at different dose rates.

It is anticipated that the results of this project will have direct bearing on the interpretation of another experiment, currently sponsored by the AECB, which will measure the influence of dose rate on the induction of myeloid leukemia produced by a predetermined low dose of gamma radiation. In addition, this project will allow a more complete understanding of the biological processes which control the probability of carcinogenesis when the same total radiation exposure is delivered in different ways. These results will impact on the standards set to regulate exposures received at low dose rate or as split doses.

Proponent	REPD
Technical Advisor/Evaluator	REPD (C. Pomroy, K. Bundy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$40k	$18k	$93k

Earlier Directly-Related Contracts and Funding:

7.165.1 The Influence of Radon Daughter Exposure on Cell Mitosis Rate

It is proposed to determine the influence of exposure to radon decay products on the rate of mitosis (cell division) of cells of the bronchial epithelium of rats. The relationship among exposure to radon decay products, cell mitotic activity and incidence of lung cancer will be investigated. This study will be a feasibility study to determine whether the biochemical techniques referred to in the following paragraph are sufficiently well developed to proceed with a large-scale project.

A great number of laboratory animals (> 20,000) have been exposed to radon progeny in several countries, such as France. The incidence of lung cancer per unit exposure is known and well documented. Tissues from these animals have been kept and are available for further analysis. In AECB project 4.121.2, "The Proliferative Cells Of The Human Bronchial Epithelium", it was demonstrated that the techniques exist for identifying cells that are in a specified stage of mitosis. Furthermore, one expert review panelist indicated that new currently-available techniques can identify cells that have been fixed (all metabolic activity and deterioration stopped) while at specified stages of mitosis. Since dividing cells are more prone to pre-cancerous mutations than non-dividing cells when exposed to radiation, the ratio of dividing to non-dividing cells is an index of radiosensitivity. This project is proposed because, at present, very little is known of the fundamental mechanisms of radio-carcinogenesis.

It is anticipated that the results of this study will indicate whether the biochemical techniques exist that are required for a study to determine whether alpha radiation can accelerate or stimulate mitotic activity in bronchial epithelial tissue, thereby making more cells available for pre-cancerous mutations than would otherwise be present.

Proponent	REPD
Technical Advisor/Evaluator	REPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

7.166.1 Birth Defects Due to In Utero Exposure to Ionizing Radiation

It is proposed to conduct a pilot study to determine the feasibility of a full-scale study of birth defects among children who were exposed in utero during fluoroscopic examination of their mothers during treatment for tuberculosis at several sanatoria in Nova Scotia and elsewhere in Canada during the period from 1930 to 1952. The feasibility study (involving about 45,000 women mostly in their 20s) will examine the availability of adequate information to calculate the dose to the fetus, to ascertain the different types of birth defects, including mental retardation, as a function of age and other relevant factors.

It is known that in utero exposure of pregnant women to ionizing radiation might cause birth defects among their offspring. The magnitude of the risk of radiation-induced birth defects depends on several factors, including the dose to the fetus, the rate at which the dose is delivered, and the stage of gestation and nutritional conditions at the time of radiation exposure. The currently used risk estimates for radiation-induced birth defects have a wide margin of uncertainties due to errors associated with each of these factors. Since more and more Canadian women of child-bearing age are entering the work force in the nuclear industry, it is important to improve the accuracy of the risk estimates for radiation-induced birth defects and to understand the influence of these factors on the risk estimates.

It is anticipated that the results of this pilot study will enable the AECB to determine the feasibility of a full-scale study. If a full-scale study is found to be feasible, then the results of such a study will improve the accuracy of risk estimates for radiation-induced birth defects. (This project is expected to be a joint study with the National Cancer Institute of Canada on an equal cost sharing basis. The total cost to the AECB is expected to be $40k.)

Proponent	REPD, HES, National Cancer Institute of Canada
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$20k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

7.167.1 Risk Estimates for Radiation-Induced Genetic Disorders

It is intended to conduct a study to obtain improved risk estimates for radiation-induced genetic disorders. This study consists of two parts, laboratory experiments and mathematical modelling. In the first part, biological samples obtained from humans who are known to have inherited disorders, including multifactorial disorders, will be analyzed and the mutation rates for a variety of end points will be estimated. The rates will then be compared with the results obtained from animals exposed to different doses of ionizing radiation, and, subsequently, a set of probable values of relevant genetic parameters will be deduced. These parameters will be substituted into a suitably developed mathematical model, and improved risk estimates will be obtained. The mathematical model will be used to calculate the uncertainty in the risk estimates.

Currently-used risk estimates for radiation-induced genetic disorders are derived from the observations of dominant and recessive types of genetic disorders, which constitute only 1-2% of the total genetic load in the offspring of the exposed parents. Contribution to the risk estimates, from the remaining 98-99% of the disorders (multifactorial disorders) have been estimated using a number of assumptions, and some of these assumptions are now known to be associated with large uncertainties. Consequently, the overall risk estimates for radiation-induced genetic disorders may be associated with large uncertainties. The possible uncertainties in these assumptions have been discussed in the recent reports of the BEIR V and UNSCEAR 1988 Committees. Professor Sankar (a consultant to UNSCEAR) and Professors Yasuda of Japan, and Czeizel and Tusnady of Hungary, who are international experts in the field of radiation-induced genetic disorders have come up with a design to conduct a study to overcome this major uncertainty.

It is anticipated that the results on this study will improve the risk estimates for radiation-induced genetic disorders, which, in turn, will help to improve the weighting factors used to calculate the effective dose equivalent. (This is a joint study with: Leiden University, Netherlands; National Institute of Radiological Sciences, Chiba, Japan; Mathematical Academy of Sciences, Budapest, Hungary; and National Institute of Hygiene, Budapest, Hungary. Additionally, a grant of $120k is expected from the Commission of the European Communities. The total cost of this multi-year project is expected to be $900k, with a total contribution from the AECB of about $80k).

Proponent	REPD, HES et al. (see list above)
Technical Advisor/Evaluator	REPD
Project Manager	V. Elaguppillai
Review Panel	
Contractor	State University of Leiden, The Netherlands
Principal Investigator	Professor K. Sankaranarayanan
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$30k	$25k	$25k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

7.168.1 Recovery of Boreal Forest Vegetation

It is intended to study the recovery of boreal forest vegetation communities following 12 years of exposure to chronic gamma irradiation.

This project is proposed as the concluding phase of earlier work that studied changes in vegetation during 12 years of irradiation of the forest at the field-irradiator gamma site in Manitoba. The effects of radiation on forest species and other plant communities have been documented and form a good basis to describe perturbations caused by chronic low-level radiation in a natural system. Irradiation ceased in 1985, and this presents an opportunity to study recovery of the boreal forest after radiation stress. It is intended that forest recovery be monitored to document long-term effects of gamma radiation on ecosystems. This project will be integrated with on-going international studies on effects measured near Chernobyl.

It is anticipated that this study will provide information on the long-term effects of radiation on native Canadian forests. This will allow estimation of the impact of radiation on the environment from nuclear facilities.

Proponent	REPD
Technical Advisor/Evaluator	REPD (T. Tostowaryk, L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$30k	$65k	$0k	$115k

Earlier Directly-Related Contracts and Funding:

7.169.1 Ra-226 in Deciduous Teeth of Residents Living Near Mining Areas

It is proposed to determine Ra-226 levels in deciduous (milk) teeth of residents born and raised in areas near uranium mine and mill activities in Ontario in order to evaluate deposition of radionuclides in humans through environmental transfer pathways.

Ra-226 analysis of human teeth will provide good insight into the transfer of radionuclides in the environment through, mainly, food and drinking water to humans. Radium, being an analogue of calcium tends to accumulate in tissues rich in calcium. Human tooth tissues are rich in calcium and thus form potential sites for radium accumulation. Deciduous, or milk teeth, are lost in childhood and can easily be obtained for the study.

The results of this study will provide AECB staff with information on the transfer of environmental radionuclides to humans.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (M. Légaré, T. Tostowaryk)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$45k	$0k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

7.171.1 Canadian Coordinating Committee on Chernobyl

It is intended to examine the possibility of conducting joint studies of health effects on the Chernobyl population exposed to ionizing radiation during the nuclear accident in 1986.

There is a wealth of unique information to be gained from the effects of the Chernobyl accident, but the complexity of the processes from which the information is being gathered is such that co-operative efforts are required. The AECB staff wants to determine the most effective way of participating in joint studies on the health effects of the Chernobyl accident. To achieve this objective, the AECB is requesting the services of several specialists to provide advice on the suitability, design and conduct of epidemiological studies of the Chernobyl population. The studies may be conducted in collaboration with other Canadian organizations (AECL Research, NCIC, Health and Welfare Canada) and other organizations (US-DOE, US-NCI, CEC).

It is anticipated that this project will bring to the AECB valuable information on the possible effects of an accident at a commercial nuclear reactor.

Proponent	REPD
Technical Advisor/Evaluator	REPD (R.M. Chatterjee)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$8k	$10k	$7k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

7.176.1 Biological Dosimetry Workshop

It is proposed to convene a workshop on the topics of the current status of biological dosimetry, strategies for developing and validating biological indicators of exposure to radiation, and implementing biological dosimetry as part of radiation dose monitoring.

This workshop is proposed because the assessment of dose to workers following unexpected exposure to ionizing radiation may involve interpreting biological data from various organ, tissue and fluid samples taken from the exposed individuals. Obtaining the required information requires the application of diverse techniques from a variety of scientific disciplines. This workshop will bring together physicists, chemists and radiobiologists to discuss current practices and to consider new methods for determining absorbed dose.

It is anticipated that this workshop will allow AECB staff to gain new perspectives and information pertaining to appropriate techniques for determining the dose to workers for different inadvertant exposure scenarios. (AECL is the lead agency for convening the workshop. The operating budget for the workshop is estimated at $30k. AECL is also seeking funding support for the workship from Ontario Hydro).

Proponent	REPD
Technical Advisor/Evaluator	REPD (R. Chatterjee)
Project Manager	E. Rabin
Review Panel	
Contractor	AECL
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$10k	$0k	$0k	$10k

Earlier Directly-Related Contracts and Funding:

7.177.1 Distribution of Fatal Risk in "Safe" Industries: An Update

It is proposed to update the findings of the project "Study of Fatal Risk in 'Safe' Industries" (AECB project-84.8.12, report-INFO 0206), which estimated the non-radiological risks of occupational fatalities in Ontario industries using data from the Workers' Compensation Board of Ontario for the years 1979 to 1984 inclusively, and industrial and occupational data provided by Statistics Canada from the 1981 Census (Table SPE81B41).

A weakness of the project referenced in the previous paragraph, identified by the researchers, was that for many occupations there were relatively few reported injuries from which fatal risks could be reliably predicted. This is reflected in the width of the confidence intervals calculated in the study. The project update is proposed because increasing the data base to 1990 should improve the predictive power of the regression model used, and thereby remove some of the uncertainly associated with the estimated risk for occupations with no fatal claims. In addition the current industrial safety campaign in Canada may have affected the earlier risk estimates.

It is anticipated that the results of this project will provide the AECB with a better estimate of risks to be compared with those used in the Royal Society report cited by the ICRP in ICRP 60. This will provide a measure of the relative safety of radiation work in Canada.

Proponent	REPD
Technical Advisor/Evaluator	REPD
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

7.178.1 Impact of Low Doses of Radiation on Cell Signalling

It is proposed to examine the effect of low doses and dose rates of Co-60 gamma radiation (5 total doses from 0.001 to 0.1 Gy, with a minimum of two dose rates per total dose point) on cell surface receptors that bind chemical messages called cytokines (specifically interleukins and interferons), and which consequently control the response of cells to these signals. These receptors are synthesized by the cells and are localized on the outer surface of the cell membrane. The project will test human white blood cells from normal healthy volunteers, for expression of cytokine receptors on their external surface.

This project is put forward because of the uncertainty in the impact of low doses of ionizing radiation on the risk of carcinogenesis. The study will test whether low doses of radiation alter the system by which cells respond to signals for division. The rate at which pre-cancerous or cancer cells divide can determine whether the cancer will become clinically observable before the individual dies of some other cause associasted with old age. Cell division is regulated by chemical signals (cytokines) sent by some cells and received by the same or other types of cells. These chemicals are bound by receptors on the external surfaces of the cells. That binding stimulates a series of internal cellular events which result in the signal being received by DNA (genetic material of cells). One type of signal may activate the gene(s) responsible for cell division. If exposure to low doses of radiation alters the regulation of cell surface receptors and increases their number, those affected cells will receive an inappropriately high signal to divide. If those cells are cancerous or pre-cancerous, their division rates may increase, with the corresponding consequences to the risk of cancer formation.

It is anticipated that this project will provide the AECB with information on a possible means by which very low doses of radiation may influence the risk of cancer formation. It will provide insight on the magnitude of the dose which can act in this way and a preliminary estimate of the influence of dose rates. Future follow-on work may provide quantitative estimates of changes in risk coefficients at low doses. (Co-funding with AECL will be sought)

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (M. Légaré)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$70k	$50k	$23k	$143k

Earlier Directly-Related Contracts and Funding:

7.180.1 Ethics of Identifying Radiosensitive Individuals

It is proposed to review the ethical factors involved in the identification of radiosensitive persons employable in nuclear facilities. This review will examine the social, economic, health and human rights consequences of identifying such radiosensitive individuals.

The existence of radiosensitive individuals among persons exposed to ionizing radiation might significantly influence the risk estimates for radiation-induced health detriments, which form the basis of the current dose limits recommended by the ICRP. On the other hand, the identification of radiosensitive persons in a work force might deprive them of certain occupational opportunities in the nuclear industry, resulting in social, economic, health and human rights' consequences. It is therefore important to examine the ethical consequences of identifying radiosensitive individuals in any population, taking social, economic, health and human rights' factors in account.

It is anticipated that the results of this review will give the AECB a better understanding of the impact of identifying radiosensitive individuals in the workforce of the nuclear industry. This information may also help the AECB to determine priorities for funding research in the area of human radiosensitivity.

Proponent	REPD
Technical Advisor/Evaluator	REPD
Project Manager	E. Rabin
Review Panel	24
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$10k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

7.181.1 Surname-Genetic Risk Association Study

It is proposed to conduct a pilot study to investigate the possibility of surveying Canadian data bases of medical facility usage or various disease registries, by patient surname, to determine whether the frequencies of appearance of various genetically-based diseases (such as cancer) differ for subpopulations characterized by the same surname, residing within large populations. Phase 1 of the pilot study will involve consulting with experts in records-linkage, genealogy, and studies of specific populations. Based on these consultations, a model system will be devised, in Phase 2, to access and link the requisite data bases. Phase 3 will consist of a trial run of the system in a case study of an actual population.

It is known that definable sub-populations which may tend to inbreed (e.g., such as residents of small, one-main industry towns, devout members of religious groups, etc.) differ in the frequency with which various genetically-based diseases occur. To the extent that surnames may be characteristic of such an inbreeding subset, it may be possible to use surnames to access disease frequencies in larger mixed populations for an estimate of the contribution to genetic risk from inbreeding groups. Definition of population subsets and indicator diseases of interest, together with lists of surnames which may indicate the occupations of past generations (e.g., Miner, Miller, etc.) will then be linked to see if non-random medical service usage can be correlated, including those related to cancer incidence and mortality. This project is proposed because it is possible that such population subgroups may be responsible for the occurrence of apparent elevated cancer incidence/mortality or 'cancer clusters' noted in epidemiological studies.

It is anticipated that this pilot study will lead to further work which may help to define the genetic (as opposed to environmental) contribution for anomalous incidences of cancers in poulations living in the vicinity of nuclear facilities. (Estimated total cost for the project is $250k over 3 fiscal years. Co-funding for this project will be sought from COG.)

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$25k	$75k	$125k

Earlier Directly-Related Contracts and Funding:

7.182.1 Feasibility of Performing Placental Perfusion Research

It is proposed, by means of a search of the open literature and discussions with experts in the field, to investigate the requirements for performing perfusion studies on animal placentae. *In vitro* experiments to different stages of gestation will be explored. A recommendation for performing such studies is one of the findings of the Regulatory Support Program project "Transport of Compounds from Mother to Fetus" (AECB project 7.152.1).

This study is proposed because the dose to the developing fetus from intake of radiocompounds by the mother, as determined using current internal dose calculational techniques, is highly uncertain. The parameters which characterize the transport across the placenta of most radiocompounds of importance have not been measured. Measured values for these parameters are essential for accurately estimating the dose to the fetus from radiocompounds (found in the workplace) taken in by the mother and transported to the fetus.

It is anticipated that the results of this study will suggest experimental protocols for performing placental perfusion studies, and provide information on the cost of such studies. Future placental perfusion studies using radiocompounds frequently found in the workplace should enable AECB staff to identify which compounds are largely transported across the placenta to the fetus and hence should be subject to more restrictive regulatory limits. The studies will also identify those radiocompounds for which more restrictive limits are not necessary to protect the fetus.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$12k	$0k	$0k	$12k

Earlier Directly-Related Contracts and Funding:

7.152.1	$20,000
7.158.1	$5,000

7.183.1 Genetic Risk of Exposure to Ionising Radiation

It is proposed to estimate the influence of genetic characteristics on the risk from exposure to ionizing radiation. This study will be conducted using the baseline genetic data obtained for the population of the Province of British Columbia.

Currently used risk estimates for radiation-induced genetic disorders are derived from the results of animal experiments and the baseline genetic data on human populations in Hungary, Ireland and Canada. The Canadian data was collected by Trimble and Doughty for the population of British Columbia for the period ending in 1974. Since then, an AECB-funded study was conducted by Prof. T.W. Anderson of the University of British Columbia for updating the baseline date to 1989. The update indicated some significant changes in the occurrence of certain types of genetic disorders, as compared to the previous study. It is believed that these changes might influence the overall risk estimates for radiation-induced genetic disorders and the updated B.C. data will be analyzed using Prof. Sankar's model to derive risk estimates for radiation-induced genetic disorders.

It is anticipated that the results of this study will give improved risk estimates for radiation-induced genetic disorders. (It is anticipated that the work will be done by Prof. K. Sankar, University of Leiden, The Netherlands, on a (50/50) cost-sharing basis by providing professional time free of charge. The AECB share will cover the cost of computer time used in this study.)

Proponent	REPD, HES, Univ. of Leiden
Technical Advisor/Evaluator	REPD
Project Manager	V. Elaguppillai
Review Panel	
Contractor	Prof. K. Sankar, University of Leiden, The Netherlands
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$10k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

7.184.1 Genetic Defects and Clustering Phenomena

It is proposed to develop methods by which particular epidemiological observations such as those of higher rates of cancers in particular geographical areas can be understood in terms of the relative contribution to these rates of the genetic and reproductive behavior of the affected subpopulation, as well as effects of the environment. The first phase of this project aims to develop and validate models for estimating the genetic components of oncological risk. Phase 2 will consist of direct tests of the molecular basis for cluster events using biomolecular methods to determine the segregation of existing genes that affect risk.

This project is proposed because articles have appeared recently in the literature which describe observations of the numbers of cancers in subpopulations (clusters) which are higher than expected when compared to the frequency observed in the larger reference population, assuming uniform genetic makeup. Attempts have been made to ascribe radiation exposure as the causative agent, where the studies merely point to a correlation between residence in a particular area and observed numbers of "excess" cancers. Correlations with other potential causative agents are generally not investigated. However, the cause of such clusters may be internal (genetic and biological), and not environmental. Factors which are specific to human reproductive biology, such as zygotic selection, need to be understood to determine both genetic and environmental influence on the cluster events.

It is anticipated that this study will provide the tools required to investigate the genetic and biological, as well as environmental (e.g., workplace, residence) origins of cancer cluster events which have been observed (and which may appear in the future) in geographical areas adjacent to facilities licensed by the AECB. (Estimated total cost for the project is $750k over four fiscal years. Co-funding for this project will be sought from the CANDU Owners Group.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$63k	$62k	$125k	$250k

Earlier Directly-Related Contracts and Funding:

7.185.1 Influence of TLD Position on the Estimate of Fetal Dose

It is proposed to investigate the influence of the TLD badge position with respect to the abdomen of a pregnant worker, on the relationship between the TLD reading (after exposure to ionizing radiation) and the dose to the developing fetus. This study will be performed in two phases, the second phase depending upon the findings of the first. Phase 1 will consist of a critical review of the relevant, open literature and computer programs (such as Monte Carlo codes) which have been designed to calculate doses for different radiation sources and geometries. Phase 2 will be either a Monte Carlo simulation (if a suitable program is found in Phase 1), or a laboratory study, using a phantom, appropriately configured to simulate the torso of a pregnant woman. At least two energies of gamma radiation will be utilized, as well as various radiation source-badge geometries.

This project is proposed because, for different conditions of exposure found in the workplace, such as in nuclear medicine departments, the relationship between maternal abdominal dose and fetal dose may vary. Furthermore, the dose assigned to the abdomen of a pregnant worker is derived from a single TLD badge, worn at some location about the abdomen. However, the abdomen-radiation source geometry may result in non-uniform exposure of the entire abdominal surface. To ensure that the dose to the fetus is not being underestimated, it is necessary to investigate the effect of TLD position on measurement of dose to the abdominal surface, and the relationship between dose to the abdominal surface and dose to the fetus. (To date AECB staff have no quantitative data on the significance of geometry on the TLD badge reading.)

It is anticipated that the results of this study will provide AECB staff with data with which to translate the reading from a TLD badge to the dose to the abdomen of a pregnant worker, and subsequently to fetal dose.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (M. Légaré), RTD (C. Carrier)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

7.186.1 Uncertainty in Risk Estimation

It is proposed to investigate the uncertainty in risk estimates based on Hiroshima and Nagasaki survivor populations, and on accident and medical data. It is further proposed to examine the effect of different dose and dose-rates, and background radiation, and the influence of genetics and other confounding factors on the uncertainty. The consequences of uncertainties will be examined in the context of the new ICRP dose limits.

This project is proposed because, despite many epidemiological studies, radiation risk coefficients for atomic radiation workers and the general public still remain uncertain. Such studies are based on simplifying assumptions such as a linear dose-response relationship independent of dose-rate and radiation quality, and a single radiation response for all individuals. Designing experiments on the basis of such assumptions limits their scientific value, prevents the accumulation of statistically meaningful results, and negates attempts to test cause-effect hypotheses or establish correlations such as that between radiation and cancer or other chronic diseases.

This evaluation, by testing assumptions and carrying out statistical analyses, will demonstrate the importance of appropriate design criteria. A critical examination of epidemiological studies will help in selecting meaningful data, determining the validity of current risk estimates and the errors associated with them, and providing information to assess present regulatory limits.

Proponent	REPD
Technical Advisor/Evaluator	REPD (R. Chatterjee)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

7.187.1 Natural Radiation and Radiation Index - Phase I

It is proposed to assess the feasibility and cost of mapping the level of backgound radiation in Canada.

The need for establishing an index that will indicate, to concerned populations, the levels of radiation to which they are exposed, has been expressed in certain Canadian communities. Such an index, called a radiation index, is meaningful only to the extent that the contribution of natural, inescapable sources of radiation is known. These natural sources include cosmic radiation, terrestrial radiation, atmospheric radon and thoron and their decay products, etc. An inventory of the measurements already available will be established. The magnitude and variability, both spatial and temporal, of natural radiation will be measured at a limited number of locations in Canada.

It is anticipated that this project will provide information on the feasibility and cost of establishing a Canadian map of ambient radiation levels, against which the risks from the operation of nuclear facilities may be compared.

Proponent	REPD
Technical Advisor/Evaluator	REPD (R. Chatterjee)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$30k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

7.188.1 Role of Confounding Factors on the Incidence of Down Syndrome

It is proposed to conduct a literature review of the studies of the influence of confounding factors on the incidence of Down Syndrome what, in the public's mind, may be caused by the release of radioactive material by nuclear power stations. The review will incude assessments of both animal studies and epidemiological studies on human populations.

A recent AECB-funded study (INFO-0401) has found elevated incidences of Down Syndrome among the residents of Pickering and Ajax and of a county far remote from these communities. It is possible that these relatively higher incidences might have been due to a number of confounding factors, such as maternal age, parental occupation during pre-conception periods, social habits, and exposure to chemical agents, present in these environments. Therefore, it is important to carry out a literature review to understand the influence of various confounding factors, so that these factors may be taken into account in future epidemiologcal studies of Down Syndrome around nuclear and non-nuclear facilities.

It is anticipated that the results of this study will help the AECB to understand better the influence of various confounding factors of the incidence of Down Syndrome. These factors will be taken into account in designing future epidemiological studies of Down Syndrome around nuclear and non-nuclear facilities. (This is expected to be a joint study with Ontario Ministry of Health, Bureau of Chronic Disease Epidemiology of the federal Department of National Health and Welfare and the Atomic Energy Control Board.)

Proponent	REPD, HES, Ontario Ministry of Health
Technical Advisor/Evaluator	REPD
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$15k	$0k	$0k	$15k

Earlier Directly-Related Contracts and Funding:

7.190.1 Guide on Radiation Epidemiology

It is proposed to write a guideline on the applications and limitations of the results of epidemiological studies of populations exposed to ionizing radiation. This document will serve as a training tool and guideline for the AECB staff and the general public. It will also explain epidemiology and the use of epidemiological data by giving examples based on legal cases.

In Canada, no guide of this nature exists, and none to our knowledge, is in preparation. While there are a number of documents that address the topic in a limited way, they have proven less than satisfactory for AECB purposes, they are extremely expensive, and there is no Canadian content in them. A comprehensive, specifically Canadian, guide to radiation epidemiology will be prepared by developing, combining, up-dating and "Canadianizing" the best of existing publications of this nature.

This guide will provide the AECB staff with a broad knowledge of radiation epidemiology and of the limits of the applicability of epidemiological data in the legal context. It will also provide an understanding of the subject that will be: a) scientifically accurate, and b) consistent with policy underlying legislative and regulatory schemes.

Proponent	Secretariat
Technical Advisor/Evaluator	REPD (R. Chatterjee), Secretariat (M. Bourry)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

7.191.1 Delayed Cancer and Genetic Effects from Occupational Exposures

It is proposed to utilize existing national data sources in order to examine delayed cancer and genetic effects potentially owing to occupational exposures.

This study proposes to compile an inventory of available Canadian sources of information related to the topic of occupational and environmental health. It will assess the quality and completeness of the information found in these sources and will study the feasibility of creating a lifetime occupational history of workers (longitudinal individual history). The first stage of this project will be a study on the use of income tax data, information on hiring, and the 1965-1971 Book Renewal Cards in order to obtain type of occupation and type of industry. This will be an expansion of ideas found in the National Research Council report "A Method of Monitoring Nationally for Possible Delayed Effects of Various Occupational Environments" (Newcombe) and "The Follow-Up of a 10% Sample of the Population" (Howe and Lindsay). The publication "Looking for Delayed Harm in a Mobile Population" which outlines numerous data sources will be updated, taking into account some of the recommendations of recent reports such as "The Report of the Working Group on Occupational Health Statistics" and the document "Environmental Health Issues for the 21st Century".

The results of this study will facilitate comparisons of mortality and morbidity in a number of occupational groups relative to lifetime work histories. This data will also serve to select control populations in future epidemiological studies of radiation workers and to help in interpreting the results of future epidemiological studies on the effects of radiation.

Proponent	REPD, HES, Statistics Canada
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$30k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

7.192.1 Creation of a Canadian Birth Outcome Data Base - Phase I

It is proposed to create a birth registry pilot project containing data for 1990 and 1991 that will be suitable for long-term medical follow-up studies. The full scale birth registry will be used in a number of studies where the focus is in the genetic effects of radiation on human populations. Examples of these studies are: national infant and maternal mortality rates and corresponding risk factors, socio-economic indicators (income, education, occupation) and unfavorable birth outcomes, and cluster mapping of diseases across Canada.

This project is proposed because it is important to assess the amount of radiation-induced harm that is expressed in liveborn children in terms of periods of life lost or impaired by different forms of inherited abnormality such as the incidence of leukemia in children living near nuclear facilities. These types of investigations require the use of a birth registry file, linked to an infant mortality data base. The recent publication "Task Force on New Reproductive Technologies" has increased public awareness of possible adverse reproductive outcomes in the population.

It is anticipated that the results of this pilot project will test the feasibility of using birth information in the planning of national studies where the genetic effects of radiation are of interest and where, ultimately, the full scale birth registry will help to clarify the reproductive outcome and its relationship, if any, to occupational and environmental circumstances.

Proponent	REPD, HES, Statistics Canada
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

7.193.1 Bioaccumulation of Polonium 210 and Lead 210 in the Fetus

It is proposed to measure the concentrations of Po-210 and Pb-210 in the fetuses of rodents which have been exposed to radionuclides from the U-238 decay series. (The decision to proceed with this project will depend on the findings of project 7.182.1, 'Feasibility of Performing Placental Perfusion Research'.)

This project is proposed because little is known of the transfer of these radioisotopes across the placentae of mammals. These isotopes are of special interest because they are long-lived decay products of elements to which pregnant women who work in uranium mines and mills may be exposed.

It is anticipated that the results of this project will provide information on the transfer of the radionuclides across the placenta, and thereby aid in the development of models for fetal dosimetry.

Proponent	REPD
Technical Advisor/Evaluator	REPD
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$30k	$80k

Earlier Directly-Related Contracts and Funding:

7.194.1 Environmental Contamination Model

It is proposed to fund the development of a computer code to assess the impact of accidental releases of radioactive material to the environment from nuclear facilities such as reactors and refineries.

Radiological assessment models are useful at the planning, siting and design stages as a tool to evaluate the potential consequences of hypothetical accidental releases. Such models can also be used during operations, together with the results of environmental measurements, to assess the impact of unplanned releases. While reasonably reliable methods for the evaluation of atmospheric dispersion of accidental releases exist, adequate tools for the assessment of environmental contamination following such releases do not. The short-term dynamic behaviour of radionuclides in terrestrial and aquatic ecosystems (natural, semi-natural, agricultural) cannot be adequately predicted by existing steady-state models designed to assess routine chronic releases from facilities and to derive emission limits. As AECB staff are required to assess the impact of accidental releases of radioactive materials to the environment from nuclear facilities, it is important that appropriate assessment tools are available.

The results of the project, a documented software package, will provide AECB staff with a "user-friendly" tool for realistic assessments of the environmental and radiological consequences of accidental releases from nuclear facilities.

Proponent	REPD
Technical Advisor/Evaluator	REPD (L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$30k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

7.195.1 Quality Assurance Programs in Medical Institutions

It is proposed to investigate the radiation protection practices and quality assurance programs in medical institutions with a view to promoting the implementation of the ALARA principle.

A thorough analysis of radiation protection practices in medical institutions including the management of quality assurance activities involving radioactive sources will provide information necessary to assess whether the ALARA principle is being applied, and will provide insight to help reduce the frequency and severity of unnecessary exposures.

It is anticipated that the proposed research will provide descriptions of the quality assurance programs in Canadian and foreign medical institutions and include a current listing of literature on these programs.

Proponent	GMA, RTD
Technical Advisor/Evaluator	GMA (P. Goyette), RTD (R.E. Irwin)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$10k	$15k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

7.196.1 Childhood Leukemia Among Offspring of Industrial Radiographers

It is proposed to study the incidence of childhood leukemia among the children of industrial radiographers who were exposed to external gamma radiation at their work place.

The report of the study of leukemia among children of the nuclear workers in Sellafield (U.K.) has raised concern as to the potential risk of leukemia among children of workers at Canadian nuclear facilities. Although the Sellafield study found a correlation between external gamma radiation exposure of fathers and childhood leukemia, it is not clear whether the fathers of these leukemia victims had also been exposed to internal radioactive emitters, or to chemicals present in the work place environment. In Canada, more than 2000 industrial radiographers are known to be routinely exposed to external gamma radiation at their work place, with little likelihood of being exposed to internal radioactive emitters. It is appropriate to study this population to determine whether a correlation, similar to the one reported in the British study, exists in a population exposed only to external radiation.

It is anticipated that the results of this study will help the AECB to clarify the concern as to whether or not there exists a correlation between external radiation exposure of male workers and the subsequent development of leukemia among their offspring.

Proponent	REPD, RTD, HES
Technical Advisor/Evaluator	REPD
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$30k	$25k	$0k	$55k

Earlier Directly-Related Contracts and Funding:

2.162.1	$75,000
2.162.2	$76,529
2.162.3	$5,395
2.162.4	$3,000

7.197.1 Atlas of Childhood Leukemia in Ontario

It is proposed to prepare an atlas of the geographic distribution of childhood leukemia in the Province of Ontario. The atlas will give the rate of occurrence of the disease by age, sex and by calendar year of occurrence.

A recent AECB-funded study (INFO 300-2) of the occurrence of childhood leukemia around five major nuclear facilities has raised concern as to whether or not the rate of occurrence of the disease in areas with nuclear facilities is higher or lower than that in other areas in Ontario. It is therefore important to determine the distribution of the disease by age, sex and calendar year, in Ontario, so that a meaningful comparison can be made. The Ontario Cancer Treatment and Research Foundation has been collecting the cancer data for the province for the past several years, and its data base can be used to prepare the atlas.

It is anticipated that the results of the study will enable the AECB to determine the frequency of occurrence of childhood leukemia in areas with nuclear facilities in comparison to other areas. (This project is expected to be cost-shared with the Ontario Cancer Treatment and Research Foundation, with the AECB share being 25% of the total costs.)

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

8.103.1 Testing of Foam Used in Packaging for Shock and Thermal Absorbency

It is proposed that samples of polyurethane foam, both cast in situ and from blocks, be tested for: a) energy absorption; b) load/deflection; and c) thermal resistance. Foams of different densities and from different manufacturing processes will be tested. It is expected that the load/deflector tests will be performed statically, but energy absorption should take into consideration dynamic loading.

Over the last decade there has been considerable use of polymer foam in the construction of packaging for radioactive material. This foam is used in three basic applications: impact limitation, thermal insulation, and moisture absorption. Foam is often made "in situ", filling fully closed cavities that exist in the structure. It is also supplied in bulk blocks and shapes. By alterations in materials, catalyst quantities and processes, it is possible to obtain a foam with certain required properties. Little information is available on the controlling parameters and the resulting properties. This makes difficult the enforcement of quality assurance of packaging by AECB staff.

From the results of these tests, AECB staff would be able to assess more accurately information supplied supporting applications for package and device approval. In addition, manufacturing controls can be determined with which to obtain the necessary level of quality assurance.

Proponent	RTD
Technical Advisor/Evaluator	RTD (D. Joseph)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

8.105.2 Leakage Testing on Packages for the Transport of Radioactive Materials - II

It is intended to support the attendance of Mr. W.R. Taylor at the working group ISO/TC85/SC5/WG10 which is involved in developing an international standard for leakage testing on packages for the transport of radioactive materials. This project is for his attendance at the May 1992 meeting in Paris, France.

Mr. Taylor has been participating in the development of this standard for the past several years. The AECB has benefited from his participation and has, some years ago, funded his attendance at workshop meetings.

It is anticipated that the AECB will benefit from direct and up-to-date information on the development of this international standard.

Proponent	RTD
Technical Advisor/Evaluator	RTD (J.J. McLellan)
Project Manager	M. Lupien
Review Panel	
Contractor	Taylor, W.R.
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$1k	$3k	$0k	$0k	$4k

Earlier Directly-Related Contracts and Funding:

9.102.1 Review of AECB Crisis Management Planning

It is proposed to conduct a review of AECB operations and corporate planning and, based on the latest developments in crisis management, to determine which elements of crisis management should be included in corporate planning, and in the preparation of a crisis management manual.

Although there are AECB documents that deal with emergency response at the working level (e.g. duty officer's handbook, divisional operating procedures), there is no corporate document that deals with broader questions such as: the establishment of a crisis team; communications with the public, who handles it, and how; chain of command in the absence of someone in the management structure; interaction with other government agencies; role of the AECB Emergency Response Coordinator.

The results of this review will assist AECB staff in updating corporate plans to address crisis management, and in preparing a detailed crisis management manual.

Proponent	PCS
Technical Advisor/Evaluator	PCS (B. Howden)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

9.106.2 A Review of the UCP System

A project is proposed which would take the results of a previous contract (9.106.1) which described and documented the AECB Classification System and would propose changes to the system. The changes would ensure that the system is, in principle, fair and systematic and has no built-in biases against women or minority groups.

The AECB is in the process of reviewing the Classification System, to ensure the system conforms to government standards and regulations, particularly as it relates to salary equity.

The results of the contract would be used in the on-going evaluation and development of the AECB Personnel Classification System.

Proponent	PERS
Technical Advisor/Evaluator	PERS (B. Richard)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

9.106.1	$16,000

9.109.3 Design Management Manual

It is proposed that a consultant be engaged to research and design an AECB corporate identity (house style), complete with a program symbol for use on print materials, and to prepare a standards manual for design management purposes.

The basic design principles which govern the AECB's corporate identity are governed by the Federal Identity Program (FIP), a Treasury Board policy. However, in the interests of public awareness there is a requirement to highlight the AECB's unique mandate and its independence through an appropriate, customized, and uniform look in all its visual identity items, consistent with the FIP guidelines. This should incorporate a special graphic symbol to focus attention on the AECB's regulatory program. The real possibility of a name change for the agency in the near future gives a special urgency to this project, and requires that it be completed in two versions, i.e. using both titles.

The result of this support project will be used to enhance the visual image of the AECB on initial implementation, and to maintain it in future. If and when a name change is authorized, the work will provide the essential details for the changeover of all visual identity items.

Proponent	OPI
Technical Advisor/Evaluator	OPI (H. Spence)
Project Manager	W.A. Grant
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$25k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

9.109.1	$50,000
9.109.2	$19,000

9.109.4 National Public Awareness Survey

It is proposed that the national public awareness survey conducted in 1988 be repeated by the same research firm (Contemporary Research Centre).

The 1988 survey provided a demographic profile of the Canadian public with respect to awareness of the AECB, attitudes toward the agency, significant strengths and weaknesses, and confusion of identity with AECL. A number of communications and visibility initiatives have been taken since the national poll was conducted, and a survey is needed to evaluate their effectiveness.

The results of this study would be used in planning the strategy and tactics for corporate communications over the next three to five years.

Proponent	OPI
Technical Advisor/Evaluator	OPI (H. Spence)
Project Manager	W.A. Grant
Review Panel	
Contractor	Contemporary Research Centre
Principal Investigator	
Category	3

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$55k	$0k	$0k	$55k

Earlier Directly-Related Contracts and Funding:

9.109.1	$50,000
9.109.2	$19,000
9.109.3	$25,000

9.121.1 Nuclear Terminology (English/French) Data Bank

It is intended to acquire and examine samples of English-French terminology (from existing data banks) covering terms, idioms and expressions, used in the nuclear industry and by national regulatory agencies. The purpose is to explore the extent of work required to compile a comprehensive, bilingual nuclear terminology data bank for use in Canada.

Both freelance and staff translators working on AECB material have limited terminological resources at their disposal when it comes to the jargon of such activities as reactor regulation and radiation protection. Other AECB staff creating original text in French, particularly those based on English references, are similarly handicapped. There is a consequent tendency to create mini-lexicons for personal use, with resulting problems in corporate standardization (uniformity) and accessibility. Where the AECB interfaces with francophone licensees, (e.g., in operator certification) lack of a standard lexicon can present difficulties.

The data bank will be used by all AECB personnel involved in producing or reviewing French text. Access to it will be maximized so that many others will profit from its use [cost-sharing basis].

Proponent	OPI, ACS
Technical Advisor/Evaluator	OPI (G. Plante), ACS (P. Goyette)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$30k	$30k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

9.121.2 French-English Glossary of Power-Reactors Terminology

It is intended to compile a glossary of the technical and regulatory terminology used by the operators of nuclear power reactors. This compilation will be station specific in that it will reflect the technical and regulatory terminology as it exists at present with respect to Gentilly-2 and Point Lepreau Stations, and will include a classification index for components and systems.

Such a compilation would substantially increase the efficiency of the review process of three types of Significant Event Reports from Gentilly-2 (Rapport D'événement préliminaire; Analyse d'événement significatif, et Rapport d'événement), and to a lesser extent the effectiveness of that process. Additional benefits not necessarily limited to Power Reactor Divisions would be: 1) the increased transparency of the Significant Events or other occurrences at Gentilly-2 to other groups within the AECB, and 2) the initiation of a standardization process in technical and regulatory bilingual terminology for power reactors, which is expected to be useful in other tasks such as production of Regulatory Documents and other formal publications.

The purpose of this work is primarily to increase the efficiency of the event review process within the power reactors area.

Proponent	PRDB
Technical Advisor/Evaluator	PRDB (A. Danilov)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$5k	$30k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

9.121.1 $60,000

9.125.1 Feasibility Study for a New Information Inventory System

It is proposed to conduct a design feasibility study for a new computer-based information inventory system which allows ready access to information by AECB staff and other organizations. This study will provide a catalogue of the types of information and resources available at the AECB such as files, records, data bases, analytical tools, and technical skills. It will survey the inventory systems available in the market (some of which are being used by other government departments) and recommend a system best suited for the AECB. The system considered must be accessible by personal computers via the AECB network. In addition, a cost estimate for the acquisition and installation of the recommended system will be provided.

The current information retrieval system is limited and difficult to use. For example, records are often distributed across several different files and if the user does not know which files, then the information is effectively unavailable.

As a result of this project, AECB staff and the public will be able to gain readier access to the knowledge base held in the records management system.

Proponent	IMS
Technical Advisor/Evaluator	IMS (W. Goodwin)
Project Manager	Q.S. Truong
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	91/92	92/93	93/94	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

11.128.1 Radiation Index Survey

It is intended to select a method by which proposed radiation indices can be best evaluated and to determine, through testing, which index most effectively communicates the dose information to the public in Durham Region, or whether and how one of the proposed indices can be modified to convey the information effectively.

At the invitation of the AECB, on June 13, 1991, an ad hoc committee composed of health professionals, government agency representatives, and local citizens was invited to discuss the development of a publicly acceptable index to provide information on the effects to the public of emissions from nuclear power plants in the Regional Municipality of Durham. This ad hoc committee established a working group which, on October 21, 1991, submitted a report with recommendations on how best to communicate the information to members of the public. The ad hoc committee members also suggested alternatives and changes to the report. It was suggested that qualitative research be underatken to ascertain which proposal, among 3 or 4 submitted for consideration, would most effectively present the dose information to the public in a manner which was understandable and useful.

The results of this testing will provide information on the public's preference, as well as providing suggestions for improvements. This testing will provide the basis for selecting a mechanism by which information on radiation dose levels can be effectively communicated to the public.

Proponent	O.P.I.
Technical Advisor/Evaluator	O.P.I. (B. Gerestein), REPD (R.M. Chatterfee)
Project Manager	M. Lupien
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$12k	$8k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

11.130.1 Validation of Radiological Assessment Models

It is intended to evaluate the results of relevant international research programs aimed at improving and validating radiological assessment models. It is also intended to participate actively in selected working groups within these programs, involving model testing exercises and evaluation of pathways parameters.

Environmental transfer models are used in the evaluation of the radiological impact of routine and accidental releases from nuclear facilities, and there is an ongoing need to evaluate the reliability of the model predictions. The widespread distribution of radioactive material throughout the western USSR and Europe following the Chernobyl nuclear accident has provided new opportunities for the acquisition of environmental measurement data sets appropriate for the testing and evaluation of radiological assessment models. As a result, several international research programs have been established to collate and analyze such data, and to apply the data to specific model testing exercises and transfer parameter reviews. Of particular interest to the AECB are the IAEA/CEC Coordinated Research Program on the Validation of Model Predictions (VAMP), and the Biospheric Model Validation Study (BIOMOVS II) jointly organized by Sweden, Spain and Canada. The AECB and other interested agencies in Canada are also exploring opportunities for coordinating research efforts with the CEC and with the US DOE to facilitate the scientific study of Chernobyl data. In addition, the AECB is interested in the results of a CEC-US NRC joint project being established to evaluate uncertainties in accident consequence assessment models.

It is anticipated that the acquisition of state-of-the-art scientific information on improvement and validation of radiological assessment models, through participation in such international programs by AECB staff and other Canadian experts, will assist in ensuring the credibility of regulatory decisions based on radiological assessment modelling.

Proponent	REPD, HES
Technical Advisor/Evaluator	REPD (R. Chatterjee, L. Chamney)
Project Manager	M.R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	0

Past	91/92	92/93	93/94	Future	Total
$0k	$20k	$40k	$50k	$50k	$160k

Earlier Directly-Related Contracts and Funding:

FUNDING ($K) OF
AECB REGULATORY RESEARCH AND SUPPORT PROGRAM
BY MISSION OBJECT

(FY 1992/93 ALLOCATION: $3,850K)

MISSION OBJECT	FY 1992/93 ALLOCATION ($K)		
	CATEGORIES 0, 1, 2	CATEGORY 3	TOTAL
2. Nuclear Reactors	$1,616	$1,620	$3,236
3. Other Fuel Cycle Facilities, General	$610	$515	$1,125
4. Uranium Mines and Mills	$607	$195	$802
5. Waste Management	$245	$185	$430
6. Non Fuel Cycle Applications	$145	$135	$280
7. Health Physics	$473	$1,118	$1,591
8. Transportation	$3	$35	$38
9. Regulations & Regulatory Process Development	$160	$105	$265
11. Special Services	$48	-	$48
Total	$3,907	$3,908	$7,815

LIST OF REVIEW PANELS FOR REGULATORY RESEARCH & SUPPORT PROGRAM PROJECTS

1. RADIATION-INDUCED DEVELOPMENTAL DEFECTS

Project Manager: V. Elaguppillai

In Progress:

Effects on Central Nervous System from In Utero Exposure (7.106.2)

Mechanism of Radiation-Induced Mental Retardation (7.135.1)

2. EPIDEMIOLOGY

Project Manager: V. Elaguppillai

In Progress:

Study of Childhood Cancer following Maternal X-Irradiation (7.137.1)

Paternal Exposure to Ionizing Radiation and Childhood Leukemia (7.157.1)

3. INHALATION STUDIES

Project Manager: M.R. Avadhanula

In Progress:

Study of the Health Effects of Inhaled Uranium Ore Dust - Phase 3 (4.101.3)

4. DOSIMETRIC MODELS

No 1992/93 Panel

5. LUNG SOLUBILITY STUDIES

Project Manager: K.P. Ho

In Progress:

Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities (4.103.2)

6. RELATIVE BIOLOGICAL EFFECTIVENESS (RBE)

Project Manager: E. Rabin

In Progress:

Response of Mice to Gamma Rays Delivered at Low Dose Rates (7.141.1)

7. BRONCHIAL EPITHELIUM — No 1992/93 Panel

8. RADIOSENSITIVITY OF BIOLOGICAL SYSTEMS — No 1992/93 Panel

9. URANIUM TOXICITY — No 1992/93 Panel

10. HYDROGEOLOGY — No 1992/93 Panel

11. ENVIRONMENTAL PATHWAYS

Project Manager: M.R. Avadhanula

In Progress:

Canadian Data Base for Radionuclide Transfer in the Environment (3.151.1)

12. SOFTWARE RELIABILITY — No 1992/93 Panel

13. GEOCHEMISTRY — No 1992/93 Panel

14. SEVERE ACCIDENTS — No 1992/93 Panel

15. PRESSURE TUBE CREEP BEHAVIOUR

Project Manager: J.K. Pereira

In Progress:

Ballooning of CANDU Pressure Tubes - Experimental Studies (2.184.3)

16. DEEP GEOLOGICAL DISPOSAL — No 1992/93 Panel

17. EXPOSURE EVALUATION — No 1992/93 Panel

18. EXPOSURES OF NON-MONITORED PERSONNEL — No 1992/93 Panel

19. FOETAL DOSIMETRY — No 1992/93 Panel

20. CONTACT DOSIMETRY — No 1992/93 Panel

21. NPP EQUIPMENT QUALIFICATION (Environmental and Dynamic) — No 1992/93 Panel

22. SEISMIC HAZARD

Project Manager: J.L. Wallach

In Progress:

Seismic Monitoring East and North of Toronto (2.217.1)

STANDARD ABBREVIATIONS AECB ORGANIZATIONAL UNITS

SIGLES COURANTS DES UNITÉS ORGANISATIONNELLES DE LA CCEA

Office of the President	OPR	Bureau du Président
Advisory Committee on Radiation Protection	ACRP	Comité consultatif de la radioprotection
Advisory Committee on Nuclear Safety	ACNS	Comité consultatif de la sûreté nucléaire
Secretariat	SEC	Secrétariat
Secretary to the Board	SEB	Secrétaire de la commission
Office of Public Information	OPI	Bureau d'information publique
Planning and Coordination Section	PCS	Section de la planification et de la coordination
Advisory Committee Secretariat	ACS	Secrétariat des comités consultatifs
Legal Services Unit	LSU	Services juridiques
Official Languages Advisor	CLO	Conseiller en langues officielles
Medical Liaison Officer	MLO	Agent de liaison médical
Directorate of Reactor Regulation	DRR	Direction de la réglementation des réacteurs
Power Reactor Division A	PRDA	Division A des réacteurs nucléaires
Power Reactor Division B	PRDB	Division B des réacteurs nucléaires
Operator Certification Division	OCD	Division de l'accréditation des opérateurs
Studies and Codification Division	SCD	Division des études et de la codification

Directorate of Fuel Cycle and Materials Regulation	DFC	Direction de la réglementation du cycle du combustible et des matières nucleaires
Radioisotopes and Transportation Division	RTD	Division des radioisotopes et des transports
Compliance and Laboratories Division	CLD	Division des contrôles et du laboratoire
Uranium Facilities Division	UFD	Division des installations d'uranium
Wastes and Impacts Division	WID	Division des déchets et des incidences
Directorate of Assessment and Analysis	DAA	Direction de l'analyse et de l'évaluation
Safety Evaluation Division A	SEDA	Division de l'évaluation de la sûreté (Analyse)
Safety Evaluation Division E	SEDE	Division de l'évaluation de la sûreté (Ingénierie)
Components and Quality Assurance Division	CQAD	Division des composants et de l'assurance de la qualité
Radiation and Environmental Protection Division	REPD	Division de la protection radiologique et environnementale
Directorate of Research and Safeguards	DRS	Direction de la recherche et des garanties
Non-Proliferation, Safeguards and Security Division	NSS	Division de la non-prolifération, des garanties et de la sécurité
Research and Support Division A	RSDA	Division A de la recherche et du soutien
Research and Support Division B	RSDB	Division B de la recherche et du soutienπ
Directorate of Administration	ADM	Direction de l'administration
Training Centre	TC	Centre de formation

Finance Section	FIN	Section des finances
Personnel Section	PERS	Section du personnel
Information Management Section	IMS	Section de la gestion de l'information

1992/93 Research Projects - Ranking Document

RANK	CAT.	ID NO.	TITLE
Mission	**Object 02**		
01	0	2.196.1	Statistical Review of Pressure Tube Inspection Data
02	0	2.211.1	Tritium Surface Contact Dosimetry
03	0	2.217.1	Seismic Monitoring East and North of Toronto
04	0	2.216.1	Validation of Positive Void Effect
05	0	2.228.1	Acceptance Limit for Steam Generator Tube Loss of Wall Thickness
06	0	2.179.1	Performance of Steam Generator Emergency Water Injection
07	0	2.174.2	Hydrogen Absorption-Desorption at Metal Surfaces - Phase 2
08	0	2.187.2	Operational Readiness of Filtered Air Discharge Systems - Phase 2
09	0	2.238.1	Review of Computer Codes MODTURC and PHOENICS
10	0	2.111.2	International Piping Integrity Research Group - 2
11	0	2.184.3	Ballooning of CANDU Pressure Tubes - Experimental Studies
12	0	2.153.1	Review of the GOTHIC Code and Trial Application
13	0	2.229.1	Criteria and Tools for Scientific Software Quality Measurements
14	0	2.236.1	Diagnostic Skills and Mental Model Development
15	0	2.234.3	Review of Prototype Application of Software Standards
16	0	2.255.1	Formal Methods in the Development of Computerized, Real-Time, Safety-Critical Control Systems
17	0	2.257.1	Modification of the SECT Computer Program
18	0	2.181.2	Computer Code for Contaminant Dispersion and Impact Assessment
19	1	2.258.1	Definition of Systems in Nuclear Power Plants
20	1	2.241.2	Technical Review of the CANDU-3 PSA (Phase 2)
21	1	2.206.1	Methodology for Assessment of Training Programs
22	1	2.214.2	Review of Supervisory Functions in Nuclear Power Plants - Phase II
23	1	2.231.1	Functional Block Languages and Design Methods
24	1	2.259.1	Review of the Bruce-A Fuelling Machine System
25	1	2.249.1	Compliance with Bundle Power and Channel Power Limits
26	1	2.248.1	Seismic Analysis of the Pickering Pressure Relief Duct
27	1	2.243.1	Marine Geophysics in Western Lake Ontario
28	1	2.237.1	Assessment of Psychological Capacities Requirements
29	1	2.260.1	Review of Reactor Regulating System Software
30	2	2.234.2	Evaluation of Tools and Methods for the Development of Safety Critical Software
31	1	2.203.1	Intermediate and Full Scale Tests on Hydrogen Burn Phenomena

1992/93 Research Projects - Ranking Document

RANK	CAT.	ID NO.	TITLE
32	2	2.128.4	Fire Drill Evaluation at Pickering
33	1	2.152.5	CATHENA Support Service
34	3	2.190.1	Selection of Safety Significant Components of Nuclear Power Plants for Aging Assessments
35	3	2.254.1	Uncertainties in Heavy Gas Dispersion
36	3	2.245.1	Acceptability of Spacer-Pad Wear Allowance
37	3	2.261.1	Fast Bus Transfer Schemes at CANDU Power Stations
38	3	2.126.2	Critical Channel Power Uncertainty Measurement
39	3	2.234.4	Review of Trip Computer System Specifications
40	3	2.242.2	Stratigraphy in Paleozoic Rocks in the CMBBZ
41	3	2.244.1	Elevation Determinations of Stratigraphic Contacts in the CMBBZ
42	3	2.204.1	Pressure Tube Rupture in A Closed Tank - Thermalhydraulic Loadings
43	3	2.148.2	Molten Fuel/Moderator Interaction
44	3	2.152.4	Five-Channel-per-Pass CATHENA Code for Darlington NGS
45	3	2.192.1	Effect of Sheath Strain on Critical Heat Flux
46	3	2.200.1	A Safety Course for Pressure-Tube Type Reactors
47	3	2.234.5	Review of Trip Computer Redesign
48	3	2.234.6	Review of Trip Computer Testing
49	3	2.250.1	Pressure Tube Inspection Capability
50	3	2.224.1	Emissivity of Zirconium Alloy Surfaces
51	3	2.232.1	Object Oriented Languages and Design Methods
52	3	2.225.1	Estimates of Fission Product Grain-Boundary Release
53	3	2.230.1	Testing for Software Reliability in Computer Systems
54	3	2.246.1	The Behaviour of Zirconium Alloys in Reducing Environments
55	3	2.252.1	Training for Troubleshooting Skills
56	3	2.247.1	Load Factors for the Design of CANDU Concrete Structures
57	3	2.102.1	Design, Analysis and Testing Tools for Real-Time Software
58	3	2.253.1	Information System Design and Its Impact on User Mental Workload: An Analysis of Current Work
59	3	2.105.2	Crack Propagation in Tough Ductile Materials - Carbon Steel
60	3	2.170.1	Reliability of Electrical Motors Under Accident Conditions
61	3	2.193.1	Studies of Hydrogen Combustion Phenomena in CANDU Nuclear Power Plants
62	3	2.226.1	Graphical Post Processor for Scientific Computer Codes
63	3	2.239.1	Installation and Training in the Use of Aerosol Computer Codes

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RANK	CAT.	ID NO.	TITLE
64	3	2.235.1	Processes in Radioactivity Removal
Mission	**Object 03**		
01	0	3.111.1	Evaluation of Data and Models on Uranium Metabolism - Europe
02	0	3.123.1	Influence of Macrophages on Dissolution of Uranium Compounds
03	0	3.160.1	Radionuclide Analysis in Dissolution Tests
04	0	3.111.2	Evaluation of Data and Models on Uranium Metabolism - North America
05	0	3.162.1	Monitoring Uranium Emissions from a UF6 Plant Stack
06	0	3.170.1	MAGNEC Five-Year Progress Report
07	0	3.151.1	Canadian Data Base for Radionuclide Transfer in the Environment
08	0	3.144.3	Paleoseismicity in the Saguenay Region
09	0	3.152.1	Production of Public Information Material on the Effects of Radiation
10	0	3.161.1	Radiation Facts Booklet
11	0	3.103.1	Absorbed Fraction of Ingested Uranium in Humans
12	0	3.121.3	BIOMOVS II - International Assessment of Biosphere Models
13	0	3.168.1	Environmental Health Scoping Study at BHWP
14	0	3.123.2	Macrophage Influence on Dissolution of Uranium Compounds - II
15	1	3.146.1	Canadian Atmospheric Stability Indicators
16	1	3.150.2	Effects of Radiation on Species Other than Man: Aquatic Organisms
17	3	3.174.1	Uncertainty in Environmental Pathways Analysis Models
18	3	3.175.1	Further Development of the CHER-URB Urban Contamination Model
19	3	3.144.4	Seismically-Induced Liquefaction in the Saguenay Region
20	3	3.156.2	Geology at an Apparently Seismically Active Intersection Near Lac St-Jean
21	3	3.135.2	Dosimetry of Organically Bound Tritium Derived from Diet
22	3	3.169.1	Computer Software Quality Assurance
23	3	3.164.1	Carbon-14 in Lakes: Appropriate Risk Assessment
24	3	3.173.1	Review of Soil to Plant Transfer Models
25	3	3.134.1	RBE from a Microdosimetric Approach
26	3	3.163.2	The Origin of Conical Hills, Charlevoix Seismic Zone - Phase II
27	3	3.101.2	Demonstration of the Feasibility of Directly Dating Quartz - Phase II
28	3	3.157.1	A Field Evaluation of Convoluted Laminations
29	3	3.154.1	Impact of Occupational Dose Reduction on Doses to the Public
30	3	3.172.1	Use of Evergreen Needles to Assess Airborne Radioactivity

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RANK	CAT.	ID NO.	TITLE
31	3	3.171.1	Bioavailability of Iodine in a Simplified Aquatic Food Chain
32	3	3.165.1	HTO and C-14 Cycling following Chernobyl
Mission Object 04			
01	0	4.103.2	Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities
02	0	4.106.4	Ontario Miners Mortality Study - Annual Update
03	0	4.101.2	Modification of Equipment for Uranium Ore Dust Study
04	0	4.101.3	Study of the Health Effects of Inhaled Uranium Ore Dust - Phase 3
05	0	4.130.1	Evaluation of Radon Daughter Exposures of Port Radium Miners
06	0	4.118.2	Mortality Analysis of Beaverlodge Uranium Miners from 1981-1989
07	2	4.108.2	Methodology for Determining the AMAD of Long-Lived Dust
08	2	4.130.2	Mortality Analysis of Port Radium Uranium Miners (1950-1989)
09	1	4.136.1	Representativeness of Open-Face Dust Samples
10	1	4.135.1	A Method for Measuring Uranium in Dust Samples
11	3	4.108.3	Time Variability of AMAD of Long-Lived Radioactive Dust
12	3	4.132.1	Smoking Histories of Fluorspar Miners
13	3	4.133.1	Lung Cancer Among Uranium Miners in Germany
14	3	4.134.1	Tools for Measuring the Unattached Fraction for Uranium Mines
15	3	4.112.1	Electrical Charge of Radioactive Aerosols in Uranium Mines
16	3	4.126.1	Computerized Mortality Search Procedures
Mission Object 05			
01	0	5.137.1	Study of Radionuclides in the Lichen-Caribou-Man Food Chain
02	0	5.146.1	Thermal Consolidation Effects Around a High Level Waste Repository
03	0	5.144.1	Groundwater Inflow into Deep Underground Mines - Phase I
04	0	5.127.2	Radionuclide Concentrations in Fish: Phase 2 (Detailed Analyses)
05	0	5.149.1	Radiological Impact of Uranium Mining: Ontario
06	2	5.144.2	Groundwater Inflow Into Deep Underground Mines - Phase II
07	1	5.143.2	Radiological Impact of Uranium Mining: Northern Saskatchewan - Phase II
08	3	5.152.1	Effects of Low-Level Radiation on Fish - Phase I
09	3	5.148.1	Reassessment of the Deep Lake Disposal of Uranium Tailings
10	3	5.147.1	Assessment of the Underground Disposal of Tailings Concept
11	3	5.150.1	Concentrations of Radionuclides in Wild Rice

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RANK	CAT.	ID NO.	TITLE
12	3	5.129.1	Decommissioning of Open Pit Mines - Literature Survey
Mission Object 06			
01	0	6.113.1	Study of Radioisotopes in Municipal Waste Disposal Systems
02	0	6.118.1	Assessment of Tc-99m Bioassay in Medical Work Environments
03	2	6.104.2	Production of a Hospital Radiation Safety Officer's Handbook - II
04	3	6.120.1	Doses from Industrial Radiographic Exposure Devices
05	3	6.119.1	Occupational Radiation Doses to Health Care Workers
06	3	6.117.1	Radioisotopes Reference Manual & Data Base
Mission Object 07			
01	0	7.093.1	Epidemiology of Lung Cancer Mortality in Canadian Mining Communities
02	0	7.135.1	Mechanism of Radiation-Induced Mental Retardation
03	0	7.141.1	Response of Mice to Gamma Rays Delivered at Low Dose Rates
04	0	7.153.1	RBE of Tritium and Co-60 Gamma Rays at Low and High Dose Rates
05	0	7.171.1	Canadian Coordinating Committee on Chernobyl
06	0	7.117.1	Hospital Record-Keeping System for Epidemiological Studies
07	0	7.142.1	Mortality Analysis of the Fluorspar Miners from 1985-1990
08	0	7.137.1	Study of Childhood Cancer following Maternal X-Irradiation - Phase 1
09	0	7.162.1	Assessment of Biases Due to Measurement Errors on Risk Estimates
10	0	7.167.1	Risk Estimates for Radiation-Induced Genetic Disorders
11	0	7.122.2	Expanded Cancer Incidence Linkage for the Canadian Study of Cancer following Multiple Fluoroscopies
12	0	7.106.2	Effects of In Utero Exposure on Central Nervous System
13	0	7.168.1	Recovery of Boreal Forest Vegetation
14	1	7.176.1	Biological Dosimetry Workshop
15	1	7.160.1	Metabolism and Fetal Dosimetry of Tritium
16	1	7.186.1	Uncertainty in Risk Estimation
17	1	7.143.1	Canadian Cancer Data Base
18	3	7.143.2	Development of a New 1951-1990 Master Identification File
19	3	7.143.3	Linkage of National Dose Registry to the Cancer Incidence Data Base
20	3	7.197.1	Atlas of Childhood Leukemia in Ontario
21	3	7.181.1	Surname-Genetic Risk Association Study
22	3	7.196.1	Childhood Leukemia Among Offspring of Industrial Radiographers

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RANK	CAT.	ID NO.	TITLE
23	3	7.166.1	Birth Defects Due to In Utero Exposure to Ionizing Radiation
24	3	7.177.1	Distribution of Fatal Risk in "Safe" Industries: An Update
25	3	7.161.1	Literature Review: Interaction Radiation - Co-Carcinogens
26	3	7.185.1	Influence of TLD Position on the Estimate of Fetal Dose
27	3	7.195.1	Quality Assurance Programs in Medical Institutions
28	3	7.183.1	Genetic Risk of Exposure to Ionising Radiation
29	3	7.184.1	Genetic Defects and Clustering Phenomena
30	3	7.188.1	Role of Confounding Factors on the Incidence of Down Syndrome
31	3	7.191.1	Delayed Cancer and Genetic Effects from Occupational Exposures
32	3	7.190.1	Guide on Radiation Epidemiology
33	3	7.180.1	Ethics of Identifying Radiosensitive Individuals
34	3	7.194.1	Environmental Contamination Model
35	3	7.187.1	Natural Radiation and Radiation Index - Phase I
36	3	7.116.1	Cancer Morbidity Follow-Up Feasibility Study
37	3	7.133.1	Bone Cancer from Radionuclide Intake
38	3	7.169.1	Ra-226 in Deciduous Teeth of Residents Living Near Mining Areas
39	3	7.192.1	Creation of a Canadian Birth Outcome Data Base - Phase I
40	3	7.182.1	Feasibility of Performing Placental Perfusion Research
41	3	7.193.1	Bioaccumulation of Polonium 210 and Lead 210 in the Fetus
42	3	7.163.1	Alteration of Immune Surveillance and DNA Repair Capacity
43	3	7.128.1	The Relative Impact of Radiation-Induced Genetic Disorders
44	3	7.127.1	Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens
45	3	7.148.1	The Combined Effects of Radiation and Chemical Substances
46	3	7.149.1	Biological Dosimetry
47	3	7.178.1	Impact of Low Doses of Radiation on Cell Signalling
48	3	7.165.1	The Influence of Radon Daughter Exposure on Cell Mitosis Rate
49	3	7.093.2	Epidemiology of Lung Cancer in a Canadian Mining Community
Mission	**Object 08**		
01	0	8.105.2	Leakage Testing on Packages for the Transport of Radioactive Materials - II
02	3	8.103.1	Testing of Foam Used in Packaging for Shock and Thermal Absorbency
Mission	**Object 09**		
01	0	9.121.2	French-English Glossary of Power-Reactors Terminology

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RANK	CAT.	ID NO.	TITLE
02	0	9.121.1	Nuclear Terminology (English/French) Data Bank
03	1	9.106.2	A Review of the UCP System
04	1	9.125.1	Feasibility Study for a New Information Inventory System
05	3	9.109.4	National Public Awareness Survey
06	3	9.109.3	Design Management Manual
07	3	9.102.1	Review of AECB Crisis Management Planning
Mission Object 11			
01	0	11.128.1	Radiation Index Survey
02	0	11.130.1	Validation of Radiological Assessment Models